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EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

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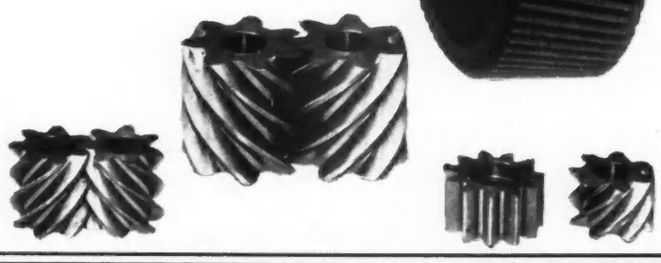

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THE STORY OF ATOMIC ENERGY.

IX.—PROGRESS UP TO THE FIRST ARTIFICIAL TRANSMUTATION.

By DR. FREDERICK SODDY, F.R.S.*

(*Concluded from page* 221.)

THE ODD AND EVEN ELEMENTS.

THE most striking result of the determination of the isotopic composition of the elements shown in Table II, on pages 220 and 221, *ante*, is the difference between the elements of odd and even atomic numbers. The even are all complex (with the single doubtful exception of No. 90, thorium) and 43 together have 223 isotopes, an average of over five each; whereas, of 40 of the odd, 20 are single and the rest are pairs of which the masses are consecutive odd numbers. The very first case of the latter to be made out was the common element chlorine (Atomic Weight 35·46, Atomic No. 17), the two isotopes having masses of 35 and 37. This is equally true for all that are not single elements, though, for a few light elements, the mass numbers are consecutive. As yet no very satisfying theoretical explanation has been advanced. Clearly it is of prime importance in the still very little understood problem of the nature of the nucleus. However, this is a comparatively recent generalisation.

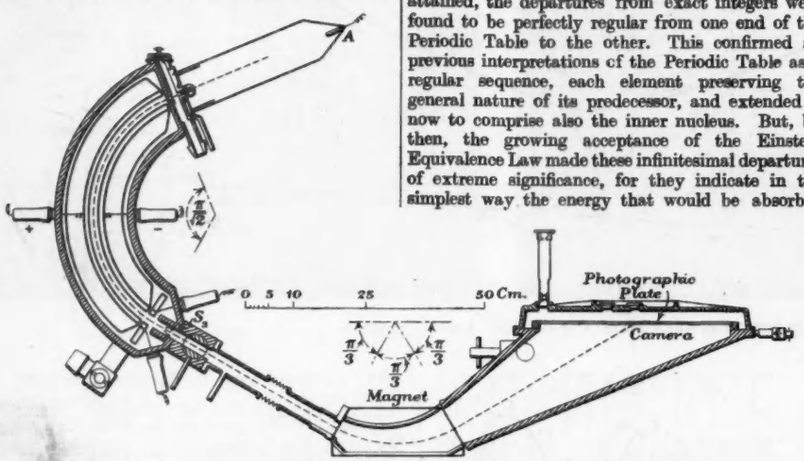


FIG. 68. DOUBLE-FOCUSING MASS SPECTROGRAPH OF BAINBRIDGE AND JORDAN.

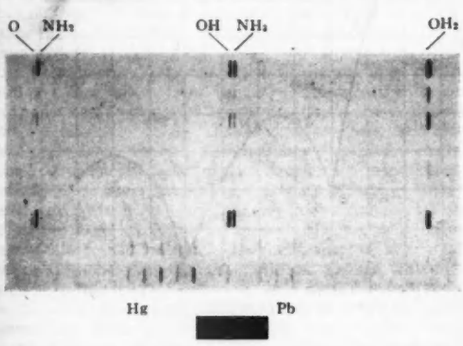


FIG. 69. MASS SPECTRUM TAKEN WITH BAINBRIDGE AND JORDAN APPARATUS.

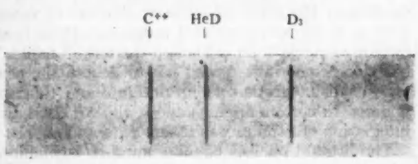


FIG. 70. "MATCHED TRIPLET" OF MASS NUMBER 6. ENLARGED 5 TIMES.

PROUT'S HYPOTHESIS REVIVED.

What Aston found at once was that all isotopic masses were approximately integral in terms of oxygen as 16, thus reviving Prout's hypothesis in modern form, that the atoms are compounded out of the same unit or "protyle." Secondly, when the extreme degrees of accuracy mentioned had been attained, the departures from exact integers were found to be perfectly regular from one end of the Periodic Table to the other. This confirmed all previous interpretations of the Periodic Table as a regular sequence, each element preserving the general nature of its predecessor, and extended it now to comprise also the inner nucleus. But, by then, the growing acceptance of the Einstein Equivalence Law made these infinitesimal departures of extreme significance, for they indicate in the simplest way the energy that would be absorbed or released in the change of one element into others.

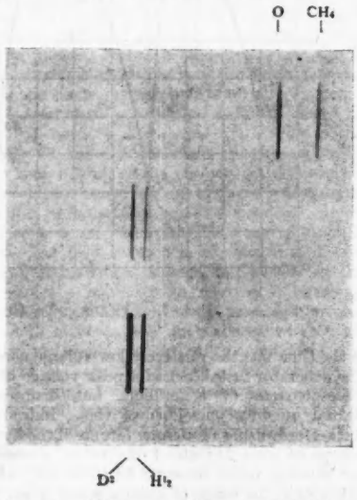


FIG. 71. "MATCHED DOUBLETS" (×5) OF MASS NUMBER 6 (UPPER) AND 4 (LOWER).

Fig. 68 shows the double-focusing mass-spectrograph of Bainbridge and Jordan, of Harvard University, which is probably the most perfect of these instruments yet designed. In the illustration the plane of the paper is the vertical plane, and the whole is mounted on the massive electromagnet. The required positive ions are generated in the glass discharge tube A, high on the left, and the photographic plate, film side down, is on the right, the whole apparatus being kept at an extreme degree of exhaustion. The electrostatic deviation of the ions is first effected by traversing the curved condenser, the plates of which are concentric cylinders, to an angle $\frac{\pi}{\sqrt{2}}$ (127 deg.) to their original direction, which spreads them out, normally to their direction of travel, according to their energy into an "energy spectrum." They so pass the wide slit S_2, travel straight a distance of 44 cm. but continuing to diverge as a conical beam, and are then deflected in the same sense as before 60 deg. by the electromagnet. The effect of this is to focus the beam into a mass-spectrum on the photographic plate, from left to right nearly linearly proportional to the ratio of the mass to the charge of the ions. The resolving power is so perfect that the photographs can be enlarged five times without loss of sharpness. The path of the ions is 1·5 m., and a vacuum of a millionth of a millimetre must be aimed at. Fig. 69 is a reproduction of a natural-size photograph taken with the Bainbridge and Jordan apparatus. The central doublet is the mass number 17, due to OH^+ and NH_3^+, with mass numbers 16 due to O^+ and NH_2^+ and 18 (OH_2^+) on each side, the width of the doublets revealing the magnitude of the Aston fraction of nitrogen and hydrogen. The lower set, taken with different electric and magnetic fields, shows the isotopes of mercury on the left and lead on the right. The black rectangle underneath represents the width the single line would have without the magnetic re-focusing of the first energy spectrum. Fig. 70 shows a photograph, enlarged five times, of the "matched triplet" of mass number 6, due to the doubly-charged carbon ion and singly-charged molecules of deuterium on the right and of a deuterium atom linked to a helium atom in the centre. Fig. 71 is a reproduction of a similar photograph for mass number 16 at the top, showing the difference of mass of the oxygen atom and methane (CH_4) molecule, and, for the lower doublet, the mass difference between the deuterium atom and the hydrogen molecule H_2, mass number 4.

Aston's first instrument rivalled in accuracy the finest chemical atomic weight determinations, and all the others far surpass them. Anyone with any imagination capable of understanding exactly what Figs. 70 and 71, for example, really measure, will not have any difficulty in agreeing with the description of the mass-spectrograph as probably the most marvellous measuring instrument invented by the human brain.

THE ASTON FRACTION.

The departure from exact integers Aston termed the packing fraction, a name which now is misleading, since the discovery of the neutron, and ought no longer to be retained, for the neutron's mass (1·009) is greater than the combined mass of the proton (1·008) and electron (0·0005), not less, whereas when the term was coined, the closer packing of, for example, helium from 4 atoms of hydrogen was thought to explain the loss of mass. Aston died in November, 1945, but for long before, the writer had preferred the term Aston fraction, and this, surely, is the name by which it should now be known. It is the parts per ten-thousand of the mass of an isotope by which it departs from an exact integer. The absolute values depend to some slight extent on the standard, but that is of little importance. Actually, for this purpose, oxygen is taken as 16, as the physical standard, meaning the mass of the pure isotope which is in overwhelming preponderance. This would make the chemical atomic weight, of the natural mixture of three isotopes, 16, 17 and 18, about 16·0043.

The general form of the departure is that the Aston fraction is relatively large and positive for hydrogen, rapidly falls and is, of course, zero at 16. It then becomes a small negative value reaching a minimum at mass 55–60, again increases, is zero at lead (207) and becomes definitely positive again for the radioactive elements. For uranium it is + 3·7 and for thorium + 3·0. This means that, in their complete change into lead and helium, there is a total energy production of 54 and 43·6 M.e.v., which is in good agreement with experiment.

The diagram Fig. 72*, on page 266, shows the relationship between the mass numbers and the Aston fraction. The lower curve, for which the scale of the vertical axis is on the left, represents the Aston (or Packing) Fraction, as parts per 10,000 by which the mass numbers, plotted on the horizontal axis, differ from integral values. With the exception of He, C, and O, all multiples of 4, the curve lies on an hyperbola approximately, cutting the zero at fluorine, 19, rising from this point steeply to the left to hydrogen, and on the right reaching a

* We have arranged with Dr. Soddy to publish his new book, *The Story of Atomic Energy*, in the form of a series of articles which are appearing at fortnightly intervals approximately. Dr. Soddy, however, retains the copyright, therefore no extract may be made from these articles without his permission.—ED. E.

* Fig. 72 has been copied from *Mass Spectra and Isotopes*, by F. W. Aston. Edward Arnold and Company, London, 1933.

THE STORY OF ATOMIC ENERGY.

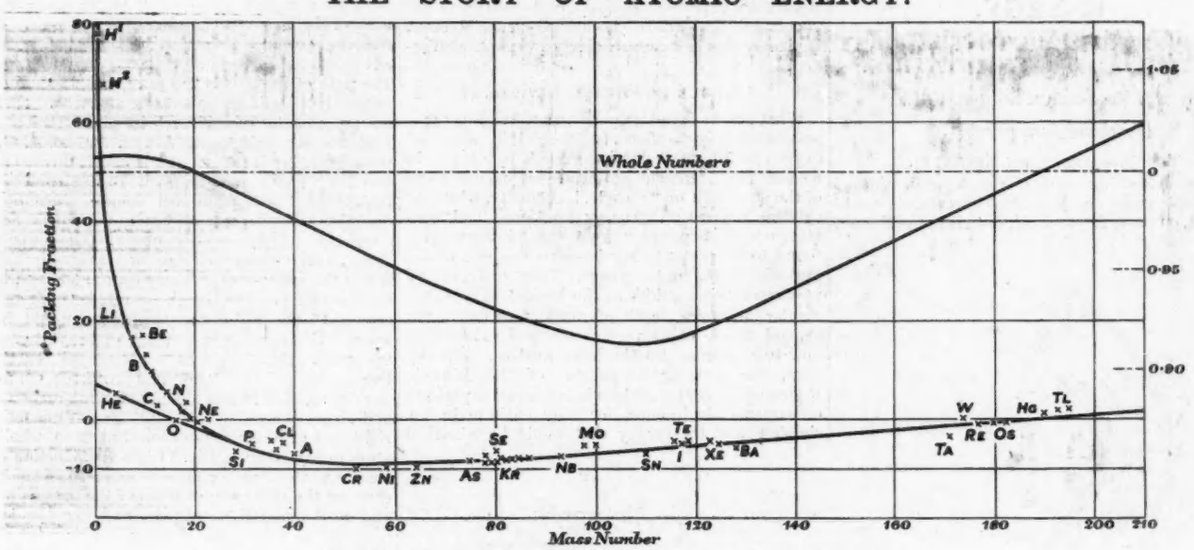


Fig. 72. Relation Between Mass Number and Aston Fraction.

minimum at the elements of the iron group, from which it rises slowly, reaching zero at about mercury and becoming positive for the radio-elements, not included. The upper curve refers to the scale on the right as regards the vertical axis, and represents the actual departures from integral value of the exact isotopic weight, the right-hand part being only very roughly accurate. Aston drew attention to the minimum for the first curve falling in the region of iron—on some views perhaps the most abundant element in the earth as a whole—and the minimum of the other falling at tin, in the region where the number of existing isotopes per element reaches a maximum.

Going back from lead, the Aston fraction becomes negative, reaching the minimum — 10 between chromium and nickel, and then rising again to the zero at the standard 16 for oxygen. From this point, a great distinction exists between the odd and even-numbered elements. For the odd, it is + 5·4 for nitrogen, + 11·7 for boron, + 26 for lithium, and + 81·2 for hydrogen. For the even, the increase, except for beryllium, is much less, the Aston fraction being + 3·2 for carbon, + 16·6 for beryllium and + 10·2 for helium. These minute figures are a veritable guide to modern alchemy.

Oliphant has shown that, if the relation briefly sketched is accurately plotted as a curve, pronounced minima occur at the mass numbers which are multiples of four. This is one of numerous indications that helium, at least in potential or embryonic form, is a subconstituent of the nucleus. Fig. 73 is Oliphant's curve of isotopic mass differences, showing, for the elements up to mass number 20, the minima for multiples of four. The larger circles in Fig. 73, indicate unstable atoms. Note the position of the unstable Lithium isotope of mass number 8 as the one of maximum known energy.

It is to be noted that the Aston fraction is by far the greatest for hydrogen, namely, over three times greater than for the next highest, lithium, which, in turn, with the exception of beryllium, is over twice the value of the next highest, boron, which again, is over double any other. Hence, nothing further was needed to indicate, as the easiest targets to aim at in any attempt on artificial transmutation, the light elements of odd atomic number and beryllium, and this soon proved to be correct.

The First Artificial Transmutation.

On April 28, 1932, at a meeting of the Royal Society, Lord Rutherford announced that two of the workers in the Cavendish Laboratory, J. D. Cockcroft and E. T. S. Walton, had successfully disintegrated the nuclei of lithium and other light elements by protons entirely artificially generated by high electric potentials. The most surprising feature

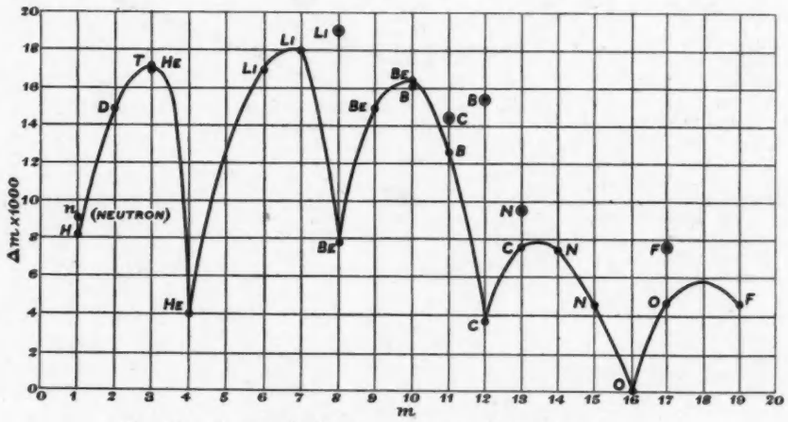


Fig. 73. Oliphant's Curve of Isotopic Mass Differences.

at the time was the relatively low voltage necessary. The generator installed had a peak voltage of about three-quarters of a million, but disintegration started at only one-sixth of this. Indeed, later Rutherford, using deuterons (atoms of the hydrogen isotope of mass 2) instead of protons, pushed back the starting point to some 20 to 40 kV, which is well within the range of quite a small X-ray induction coil.

The protons were generated in a long vertical hydrogen vacuum-tube, specially designed to withstand the high voltage, and with a window of the thinnest possible mica leaf at the end, through which they emerged to impinge on the element being bombarded. The protons were estimated to have a velocity of one-thirtieth of that of light, and their range in air was only 1 cm. The bombarded substance was examined by the scintillations produced in zinc sulphide, through a screen thick enough to absorb the protons. At 125 kV, bright scintillations, in every respect identical with those produced by the fastest normal α-rays of thorium, began to appear, and, as the voltage was increased, their number rapidly increased, but not their range or the brightness of the scintillations. At 400 kV, several hundred a minute were counted. At 250 kV, one scintillation resulted from about one thousand million protons.

The Fission of the Lithium Nucleus.

The proton, however, has only one-sixtieth of the kinetic energy of the α-particles produced. This showed that they merely pulled the trigger and released energy from the lithium nucleus. The scintillations were proved to be due to veritable α-particles of some 8·76 M.e.v. energy, which is practically the same as those of thorium of range 8·6 cm. in air, and somewhat faster than those from radium of range 7 cm. Though the term "fission" has since come into special use to denote the new type of disintegration which uranium and thorium undergo in certain circumstances, this artificial disintegration of lithium was fission pure and simple.

The lithium nucleus of mass number 7 combines with the proton of mass number one, momentarily to produce the unstable beryllium isotope of mass number 8, which instantly splits into equal parts, giving two α-particles or helium nuclei. In this production, from 7 grams of lithium and one of hydrogen to 8 grams of helium, approximately, there is a loss of 0·0181 gram, equivalent to 17·1 M.e.v., due to the Aston fraction of hydrogen and lithium being so much greater than that of helium. This is in good accord with each particle receiving some 8·76 M.e.v., especially if the kinetic energy of the bombarding proton is reckoned in.

Also, some of the unstable beryllium nuclei produced from the lithium, emit, before fission, a γ-photon of no less than 17 M.e.v., which at the time was an unprecedented energy for these rays, the subsequent fission into two helium atoms then occurring with relatively little energy. By using deuterons instead of protons, the lithium isotope of mass 6, acts much like that of mass 7 with protons, but the energy released is even greater, namely, 22 M.e.v.

THE STORY OF ATOMIC ENERGY.

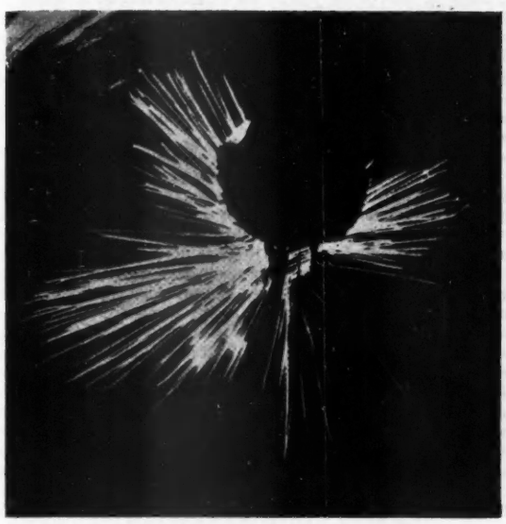


FIG. 74. BOMBARDMENT OF LITHIUM BY PROTONS.

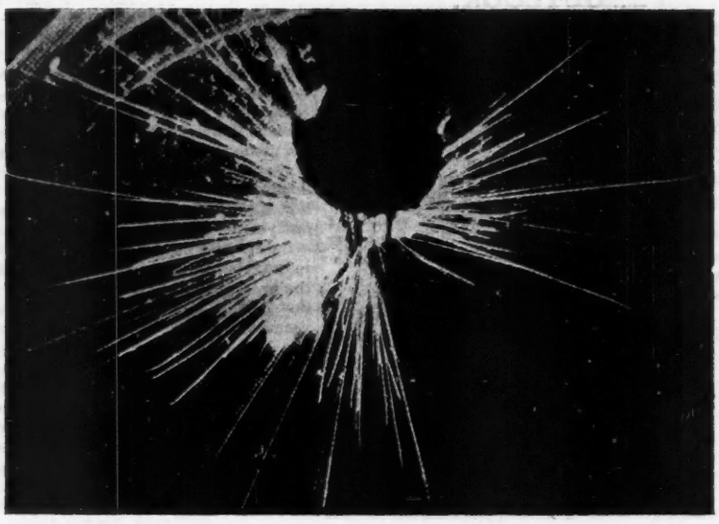


FIG. 75. BOMBARDMENT OF LITHIUM BY DEUTERONS.

THE ENERGY EVOLVED FROM LITHIUM.

It is noteworthy that, weight for weight, 17 M.e.v. energy is some ten times the energy given out in the complete disintegration of uranium and thorium into lead and helium, in their natural radioactive change, and is twice as great as in their artificial fission; but in the latter less than 1 per cent. of the mass undergoes fission. The synthesis of helium from hydrogen, already discussed, would give about four times more energy than this disintegration of lithium; but apart from this, the disintegration of the latter by protons or deuterons, affords, weight for weight, more energy than any other possible transmutational change, the complete "annihilation" of matter into energy, of course, not being included. In the writer's view, if ever atomic energy is to enter much into use in everyday economics, it seems more likely to be through the artificial large-scale transmutation of the light than of the heavy elements already accomplished, though at present in this field we are, so far as is made known, as far away from realisation as in 1932. In the pioneering work described, similar results were obtained from beryllium, boron, carbon, fluorine and aluminium, though, as is to be expected, the ranges of the expelled particles were much less, and the potential required is in no case as low, as for lithium.

Figs. 74 and 75 are reproductions of Wilson chamber photographs obtained by Dee and Walton, illustrating the artificial disintegration of lithium. Fig. 74 shows the bombardment of the lithium target by protons. Here the lithium isotope of mass 7 combines with the proton to form the unstable beryllium isotope of mass 8, which breaks up giving two α-particles of the same range. Fig. 75 shows the bombardment of lithium by deuterons. Here the lithium isotope of mass number 6 combines with the deuteron to give the unstable beryllium isotope as before, which breaks up with much greater energy giving two α-particles of 13 cm. range in air. In other cases, the neutron of the deuteron sticks to the lithium nucleus forming the isotope of mass number 7, and the proton is expelled, producing the fainter tracks traversing the chamber; whereas the lithium isotope of mass number 7 produces neutrons as well as α-particles, the latter of all ranges up to 8 cm., which are also well shown. Thus the disintegration of lithium is possible in a large number of ways which here, however, can be only briefly dealt with.

GLASGOW ENGINEERING AND FUEL EXHIBITION.—A Scientific Engineering and Fuel Efficiency Exhibition is to be held from Wednesday, March 31, until Saturday, April 17, at Kelvin Hall, Glasgow. Particulars may be obtained from the secretary at Kelvin Hall.

LITERATURE.

The Elements of Fuel Technology. By PROFESSOR GODFREY W. HIMUS. Leonard Hill, Limited, 17, Stratford-place, London, W.1. [Price 42s. net.]

Now that the production of coal is a function of the Government, and the gas and electricity works, coke-oven plants, railways and collieries, which together consume more than a third of the coal reaching the home market, will in future also constitute Government enterprises, quite an army of officials will need to have some knowledge of the technology of fuel. The time is propitious, therefore, for such a work as the present, which provides a more comprehensive survey of the whole subject of fuel and its uses than has ever been attempted before, we believe, within the compass of a single volume. The field covered is so vast that it is a matter of difficulty to make a fair survey of the contents of the book within reasonable limits of space. Starting with the geology, classification and constituents of coals, the author reviews the fuel resources and requirements of the country; the cleaning of coal for the market; the principles of combustion and boiler management; pulverised coal; gasworks and coke-oven practice; producer gas; fuel economy in furnace practice; and domestic heating. Room has also been found for information on the properties of steam, including the Mollier diagram, the loss of heat from lagged and unlagged pipes, and heat transference in boilers and furnaces.

With such a range of subjects, most of which are important enough to justify individual treatises, it has naturally been impossible to deal with most or any of them as thoroughly as an expert in any particular field would like, but the author deserves great credit for the excellence of his selection and condensation of facts. Moreover, he assists the reader by giving ample references to the literature of the respective branches at the end of each of the 22 chapters into which the work is divided. According to the preface, the book was finished by the end of 1943, when "there was no reason to doubt that the cessation of hostilities would be followed by an appreciable increase in the output of coal, possibly accompanied by some reduction in price" and when it was not foreseen that the fuel industries would be nationalised within the next three years. The author makes no comments on the effects of nationalisation, though he asserts in another place that the community as a whole was poorer under the old regime, because fortunes have been made by "speculators" who had produced coal and oil when market conditions were favourable and had then withdrawn. This would seem to imply a belief that the enterprise shown in providing fuel at a time when it was particularly wanted, and the good sense of reducing the supply when the demand diminished, were qualities to be deprecated.

The object of the author, however, is not in the least to propound political theories, but to interest the reader in the processes by which fuel is consumed or transformed, in the hope that greater technical knowledge will promote greater efficiency. Nevertheless, he does hold strongly that the purchaser should have some legal protection regarding the quality of the fuel he pays for, but suggests no practical way in which this could be given. The blending of coal to ensure consistency of quality which is very desirable in industry, and also permits the utilisation of coal of too low a grade to be marketable alone, is hardly touched on. The whole subject of blending is disposed of in half a page; but even so compendious a treatise as this cannot be expected to deal with everything. The use of semi-coke, or other smokeless fuel, for domestic heating, though admittedly more expensive than raw coal even when the value of the by-products is taken into account, is considered to be the only way of dealing with the smoke nuisance in towns, a subject on which the author feels strongly. In this connection, he states that it was not before 1875 that any special law was enacted to enforce some mitigation of the nuisance. This date appears to be wrong, for, in a discussion at the Institution of Mechanical Engineers in 1854, it was stated that there had been smoke inspectors in Manchester for many years, and the contemporary use of the phrase "Parliamentary smoke" for smoke "which allowed an object to be seen through it" would seem to imply the existence of a law on the subject. For the rest, it may be said that Professor Himus's book is readable from start to finish, and although strictly a technical work, it reviews the whole subject of fuel technology in a manner that should be comprehensible by any educated man. No practical engineer is likely to be concerned in his daily duties with more than a very small part of the ground dovered, and none will find his special branch dealt with as fully as he would like, but we feel confident that the work will be interesting and stimulating to all who study it.

"B.O.C." WELDING PRIZE.—The Council of the British Welding Research Association, 29, Park-crescent, London, W.1, have accepted an offer from the British Oxygen Company, Limited, to provide a prize fund of 100*l.* per annum for three years for a competition relating to welding. A single prize of 100*l.* is offered this year and will be awarded for the best paper presented on a research into welding or its applications. Papers must be submitted, on or before September 30, to the Association, from whom further particulars may be obtained.

THE ENGINEERING OUTLOOK.

XII.—The Light Electrical Engineering Industry.

GENERALLY, the light electrical engineering industry has experienced a high level of activity during 1947, despite the fuel crisis and shortages of certain materials. The number employed by electrical engineering firms in November was 158,600, compared with 153,100 in June, 1946. This would suggest that the contraction which followed the end of the war is over, although for some sections of light electrical engineering it is only beginning. Rising manufacturing costs and the increase of the purchase tax on electric fires, electric irons, domestic radio sets and other goods has caused a sharp drop in home sales, and many companies are finding difficulties in obtaining the volume of exports necessary for the maintenance of an economic level of production. In certain sections, therefore, a considerable reduction of employment is likely during the current year. The price factor is of primary importance, though obstacles other than high prices, such as import restrictions imposed by many overseas Governments, are contributing to the fall in sales. In general, the prospects for electrical consumer goods are uncertain, and certainly are not improved by the inability of many firms to obtain sufficient allocations of materials—particularly sheet steel—to keep their works fully occupied. The effect on costs has been serious, as have the considerable increases in the prices of certain materials. The price of copper increased by 75*l.* a ton between April, 1946, and March, 1947; that of zinc increased by 23*l.* a ton in the same period. An effect of these increases was that the price of brass increased by more than 51*l.* a ton. The Government's system of material allocation has been criticised on the ground that it has given "mushroom" firms an opportunity to market goods of inferior quality to those produced by some long-established manufacturers. The latter claimed that "equitable" allocations of materials to a large number of small firms increased their own cost of production by forcing them to work below capacity, and thus reduced the possibility of extending the export trade in these fields. It has been estimated that, as a result of insufficient supplies of materials and of local shortages of labour, the industry is producing at the rate of only about 70 per cent. of its present capacity.

There have been many important additions to the capacity of established firms since the end of the war. In the corresponding article in this series last year, details were given of the allocation of some Government factories during 1946. Several new schemes have been completed during 1947, and altogether it is now estimated that production capacity is about 20 per cent. greater than pre-war. Some of the more important expansions include the registration of two subsidiary companies of Hoover, Limited, under the name of Hoover (Electric Motors) and Hoover (Washing Machines). The former company, with an issued capital of 350,000*l.*, will take over the Hoover factory at Cambuslang, Glasgow, and will manufacture a wide range of electric motors, concentrating on the fractional horse-power sizes. The washing-machine firm, with a capital of 650,000*l.*, will take over a factory at Merthyr Tydfil. Electrical and Musical Industries, Limited, announced in December the purchase of a modern factory at Perivale from the Radio and Television Trust. The main factory of the E.M.I. group is at Hayes, Middlesex, some three miles distant. The group have also a large factory at Treorchy, in South Wales, and it is intended that all three factories will be operated largely to extend the group's export trade. Some indication of the expanded activities of the Philips electrical group was given by the raising of the issued capital of several of its associated companies, including the parent company, the Blackburn works, the Hamilton works, and the Southport works.

Important newcomers include Royal Ordnance Factories, which are being used as marginal capacity to relieve shortages of production facilities in certain fields. All products are being made in accordance with contracts with well-known electrical companies, and the marketing arrangements will be carried out by the companies themselves; there is, therefore, no question of competition. Except for ceramics manufacture, undertaken at the Swynnerton and Poole factories, production of electrical appliances is confined to a five-acre section of the Radway Green factory, Crewe. As soon as the change-over to its new peace-time use was decided upon in March, 1946, the war plant was removed and the production of electric cookers commenced. This is expected to reach about 1,000 a week. The production of electric refrigerators for Government housing schemes began during the second half of last year.

Substantial increases in output of many of the industry's products, in almost every case far above the pre-war level, have been recorded. The production data in respect of electric fires, electric irons, vacuum cleaners, electric kettles, domestic radio sets and television sets, as given in the *Monthly Digest of Statistics* for January, 1948, are given in Table I, herewith. Those in respect of refrigerating machinery, electric lamps, accumulators, batteries and insulated wire and cable are set out in Table II, taken from the same source. It would appear that, of the items in Table I, domestic appliances,

TABLE I.—*U.K. Production of Domestic Electric Appliances (Monthly Averages).*

—	Thousands.					Numbers.
	Electric Fires.	Electric Irons.	Electric Vacuum Cleaners.	Electric Kettles.	Domestic Radio Sets.*	Television Sets.
	†	†	‡	‡		
1937 ..	115	112	34	35	150	—
1945 ..	52·2	78·5	9·8	14·4	24	—
1946 ..	228·8	277·5	56·9	52·5	115	—
4th Qr.	245·5	285·9	73·8	68·5	155	1,530
1947—						
1st Qr.	183·0	222·0	70·0	70·2	142	1,789
2nd Qr.	83·5	176·5	79·1	59·0	160	2,486
3rd Qr.	73·1§	184·3§	71·3§	76·0§	151	1,932

* Including car radio sets. † Estimated. ‡ Figures for 1935. § Figures for July and August.

industry's female labour increased from 99,900 to 108,000. There was a slight increase towards the end of the year, from 48,600 in August to 50,600 in November; this suggests that, as in many other sections of engineering, the downward trend in female labour has been arrested and reversed. This also appears to be the case in the electric cable and apparatus industry, its female labour strength increasing from 133,600 in August to 138,700 in November.

Several decisions of considerable importance, affecting electrical engineering labour, were reached during the past year. In December, a specially-convened rules revision conference of the Electrical Trades Union decided to give the Executive Council permissive powers to introduce systems of payments by results "after consultation with the section of membership involved and provided there were trade union consultations at all levels in any systems agreed to." Even so cautious a consent is a step in the right direction, and it is to be hoped that the local unemployment which is likely to follow the inability of certain sections of the industry to sell their products during the coming months will not lead to a hasty abandonment of so necessary a course of action. In January, a new agreement covering the regulation of hours and wages came into effect from the first pay-day in the month. This agreement was reached by both sides of the industry's National Joint Industrial Council; it introduces a 44-hour standard working week (in place of a standard week of 47 hours) and adjustments in wages, which partly comprise an increase in the hourly rate consequent upon the shortening of the working week and partly a basic wage increase. The new rates have been stabilised until the first pay-day in September, 1948. The shorter working week may be worked over 5 or 5½ days at the sole discretion of the employer. When Saturday work is performed by operatives subject to a five-day week, time and a half is payable for all hours worked; the new standard night-shift work will be one of 43¾ hours. This represents far-reaching concessions on the part of employers, and should lead to a considerable improvement in management-labour rela-

TABLE II.—U.K. Production of Miscellaneous Light Electrical Equipment (Monthly Averages).

—	Value (£1,000).						Millions of Unit Cells.
	Insulated Wire and Cable.	Refrigerating Machinery and Parts.				Electric Lamp Bulbs.*	Accumulators.†	Dry Cells.
		Total	Domestic.	Commercial.	Industrial.			
1946—								
1st Qr. ..	2,512	—	—	—	—	712	827	79·65
2nd Qr. ..		—	—	—	—	662	871	71·64
3rd Qr. ..		624	157	320	147	715	897	75·81
4th Qr. ..		667	188	331	148	1,007	1,005	88·85
1947—								
1st Qr. ..	2,600	675	152	375	148	767	839	75·26
2nd Qr. ..	3,450	864	225	502	137	796	972	85·40
3rd Qr. ..	4,878	936	266	541	129	724	1,060	86·10
4th Qr. ..	—	1,076	353	592	131	—	1,308	—

* Including flash-lamp bulbs. † Deliveries.

the only serious fall in output during the year affected electric fires and irons, the number of fires falling from a monthly average of 245,500 during the last quarter of 1946 to 73,100 during the third quarter of 1947—some 37 per cent. below the estimated monthly average for 1937. The output of electric irons also declined, but not to the same extent—from a monthly average of 285,900 in the fourth quarter of 1946 to 184,300 in the third quarter of 1947, which is still 40 per cent. above the monthly average for 1937. The output of vacuum cleaners reached its peak (71,300 a month) during the third quarter of 1947, more than twice the pre-war figure. The output of electric kettles followed similar lines. There was a considerable increase in the number of television sets produced, which averaged 2,486 a month in the second quarter of 1947, compared with 1,580 in the last quarter of 1946. The output of domestic radio sets reached its peak in the same quarter (169,000 a month); but there was a subsequent decline, and output during the third quarter was at the pre-war level.

The shortage of labour experienced by the industry in 1947 consisted mainly of females. From June, 1946, to November, 1947, the electrical engineering

tions, and, consequently, to substantial increases in output per man-hour. This is, in fact, an express condition of the agreement.

Stoppages and strikes during 1947 were few: an unofficial strike at the works of A. V. Reyrolle and Company, involving 1,000 time-rate and 3,000 piece-rate men, began in October over an incentive bonus dispute, but a settlement was reached within ten days. A notable incentive scheme, evolved by the management of Hoover, Limited, was presented to the shareholders at a special meeting on December 1. It consisted of the conversion of 40,000 unissued 5½ per cent. cumulative preference 1*l.* shares into 800,000 "A" ordinary shares for issue to employees and executives. The scheme was vigorously opposed by some of the shareholders on the ground that it was "oppressive to the minority shareholders," but eventually it was approved. Another important event was the introduction by Crompton Parkinson, Limited, in January, of a scheme to provide bursaries annually to enable employees of exceptional promise to obtain further education and training to fit them for advancement in the company's service. A similar scheme, "Parkinson Empire Bursaries," offers engineering gradu-

ates of Australia, New Zealand and India the opportunity of obtaining practical and technical experience in the company's workshops in Great Britain.

Sir Stafford Cripps indicated in September the part that the Government expected the industry to play in the attempt to balance the nation's trade accounts. The targets for electrical goods and apparatus are given in Table III, herewith. Sir

TABLE III.—*Electrical Export Targets: Monthly Values (£ million).*

Class.	Fourth Qr., 1946.	Target, mid-1948.	Target, end of 1948.
Electrical machinery ..	1·620	1·915	2·085
Wires and cables ..	0·900	0·900	0·900
Radio apparatus	0·930	1·000	1·000
Telephone and telegraph apparatus	0·460	0·600	0·650
Lighting apparatus ..	0·330	0·450	0·500
Batteries and accumulators	0·240	0·250	0·250
Vacuum cleaners and other portable appliances	0·200	0·330	0·340
Other products	0·960	1·000	1·000

Stafford emphasised that every manufacturer had to become "export-minded" and seek foreign markets energetically, stating unequivocally that the Government would not allow goods to be diverted to the home market if any could not be sold abroad; the materials would have to be used in some other form of export. He also said that it might be necessary to increase capacity for the production of profitable lines of exports. The targets for domestic appliances and radio are, indeed, formidable, viewed in the light of increased sales resistance and import restrictions which are being imposed by various overseas Governments on those goods considered "unessential." The modest increase in the exports of the radio industry suggest that some doubt exists in the official mind whether the industry's most favourable export opportunities may not be fading. The difficulty of realising the targets for electric fires and electric irons are reflected in the reduction of output noted above.

The radio industry's contribution to exports was equivalent to a monthly rate of 581,000*l.* for the whole year 1946 (excluding telegraph and telephone apparatus) and the rate of 930,000*l.* a month in the final quarter; but there was a sharp decline in the first quarter of 1947, and the monthly average for the year was slightly less than 628,000*l.* Activity during 1947 was at a very high level, however, after an initial set-back during the first quarter owing to the fuel crisis; but production fell from a monthly average of 169,000 sets in the second quarter to 151,000 in the third quarter. There is evidence that sales have become more difficult in recent months on the home market, particularly since the autumn Budget raised the purchase tax to 50 per cent. The price factor appears to be the main obstacle to increased home sales, and there is no sign that manufacturers will be able to reduce their prices. Not all sections of the industry are equally affected; the sales of sets made by well-known manufacturers are still comparatively easy, and it is the new small firms who are suffering from the contraction of demand.

The effect of a fall in home demand is likely to be severe, leading to a rise in costs unless surplus sets can be marketed overseas. It should be realised, however, that domestic radio sets account for less than half the output of the industry as a whole. In addition to the set makers who are essentially designers and assemblers, there are three other groups of manufacturers, organised in separate associations: the valve makers, the component makers, and the makers of transmitting and electronic equipment. The valve and component makers, however, will be affected by any fall in the output of the set makers, who take the bulk of their production. Exports therefore assume special importance.

Export prospects are uncertain. Nearly half consisted of complete sets, and many overseas countries have found it necessary to stop or curtail imports for varying reasons, foremost being the shortage of currency. It is probable that the suspension of convertibility of sterling and the fast-growing dollar shortage will react in favour of British exporters (as in the case of cars) by limiting imports of American sets. It was a fact, however, that, early this year, practically the whole of Europe, with the exception of Belgium and Switzerland, was closed to British exporters. Scandinavian countries insisted on certain specifications which effectively excluded British sets. In other European countries, the competition from Holland and the United States was making sales extremely difficult. In Latin America, Argentina and Chile, the Governments have banned imports of complete sets, and others, such as Brazil, have introduced an import quota unfavourable to British exporters. An import ban was also imposed by India, in the summer of last year. In 1946, India was the best British customer, but sales have declined sharply. Exports to Egypt have been restricted by an import licensing system which practically excluded British radio sets. It is too early to say how far bilateral trading agreements will ease the situation, although it is hoped that the present trend of restrictions will be reversed.

There have been signs, also, of growing competition from the domestic industries of other countries. Argentina is now reported to possess sufficient capacity to supply all its own requirements for low-priced sets, although these are said to be of relatively poor quality. India is also said to be encouraging the establishment of complete radio plants, with the assistance of foreign capital. It is reported that a factory for the manufacture of radio and television sets and components is to be built in Bangalore, in the State of Mysore, which will be known as Mysore Airmec, Limited, and will be financed by the Government of Mysore and Airmec, Limited, of London (30 per cent. each), and by public subscription. The agreement with the British company provides for that firm to furnish technical assistance, as well as the use of designs, inventions, trade marks, plans and specifications, and will remain in force for ten years. Until production is started, Airmec, Limited, will supply radio and television sets for sale in India, the Mysore company acting as sole agents. The plan calls for the production of approximately 200,000 sets a year. In the beginning, sets will be assembled from imported components and parts, but eventually complete sets will be manufactured domestically. Other British manufacturers are endeavouring to set up assembly plants in their best markets, to maintain the level of exports in the form of components. Competition from the United States is keen, however, the prices of American sets, components and valves being substantially below those of equivalent British products. It is most important, therefore, for the industry to reduce prices wherever possible, but there are as yet no signs of successful efforts in this direction.

During 1946, American exports of radio receiving sets and components totalled 9·9*l.* million, compared with 6·2*l.* million for the British industry. The best customers were Latin-American countries, which took nearly 60 per cent. of the total, followed by Canada with 15 per cent. and Far Eastern countries with 10 per cent. Exports to Europe accounted for only 7 per cent. of the total. During the first four months of 1947, exports averaged nearly 2*l.* million a month, compared with 930,000*l.* monthly average for British exports during the last quarter of the year, a figure which has not yet been surpassed by the British industry.

The most notable events of the past year for the radio industry were its "Silver Jubilee," which was celebrated in May, and the National Radio Exhibition, held at Olympia in November. In 1897, a patent was granted to Guglielmo Marconi for an invention relating to "improvements in transmitting electrical impulses and signals and in apparatus therefor." In the same year, the British radio industry was born, and has since led the way in radio research and in the development and manufacture of the highly specialised equipment. The thermionic valve, which was the key to all that followed in radio; the short-wave beam system, itself responsible for the revolution in long-distance communication in the middle 'twenties; television, with its vast possibilities for the future; the magnetron, which generated the ultra high-frequency pulses, making it practicable, among other things, to use radar in aircraft; and radar itself, with its invaluable aids to navigation, all originated in this country.

In the export field, radar equipment and auxiliary radio products, rather than finished broadcast receivers and components, are likely to find the best market. The pre-eminence of British developments in radar is disputed only by the United States, and its products have wide new fields to conquer, including navigational aids and television apparatus, cable manufactures, and domestic equipment—all of these the latest adjuncts of the major radio companies. Companies such as A. C. Cossor, Decca, and Electric and Musical Industries have been directing their post-war researches along those lines at considerable cost; but in radio sets and components some hard battles must be expected in the export markets.

The electric-lamp industry appears to have increased its capacity to a level considerably higher than pre-war. In 1935, monthly production averaged about 8,600,000 lamps, compared with 17,000,000 during the second and third quarter of 1947. The value of production (see Table II) was greatest during the last quarter of 1946, when it averaged slightly more than 1*l.* million a month. The effect of the fuel crisis in February, 1947, was severe, reducing output to 625,000*l.* during that month, but the industry recovered gradually and, in October, output exceeded 1·1*l.* million. Exports during 1947 averaged 375,000*l.* per month, compared with 275,000*l.* in the previous year and less than 100,000*l.* in 1939. The total number employed was about 13,600 in June, 1947, and there is no evidence of any marked labour shortage. Imports during 1947 totalled 137,000*l.*, compared with about 500,000*l.* before the war

A shortage of lamp-making machinery seriously threatened production during the past year, as most of the electric-lamp manufacturing machinery used in this country has been imported hitherto from America and Germany. This has been relieved to some extent by the enterprise of the E.V.D. Engineering Company, Limited, and its associate, the Dorset Engineering Company, who are specialising in the manufacture of apparatus of this class. Three new types of machines, one for welding together the three strips of different metals which compose the leading-in wires, another for making the more complicated leading-in wires for coiled-coil lamps, and a new type of filament spiral-making machine are now being developed, and may already be available.

Progress in fluorescent-lighting methods was noted during the past year. Demonstrations of the latest types of street lighting were given by manufacturers in connection with the Association of Public Lighting Engineers' Conference, held in Southport in September. Several new systems have had operational and special tests in London and Coventry. The British Thomson-Houston Company, Limited, the General Electric Company, Limited, Stadelmann and Company, Limited, Holophane, Limited, Siemens Electric Lamps and Supplies, Limited, Engineering and Lighting Equipment, Limited, the Wardle Engineering Company, Limited, Metropolitan-Vickers Electrical Company, and others have held street demonstrations of their products. The new systems, it is reported, will compare favourably, when developed on a commercial production basis, with any other systems for city centres and busy streets, on the basis of both capital and maintenance costs.

Fluorescent lighting was recently installed as an integral part of the architectural design of a ship, the Corinth, a 15,000-ton passenger-carrying refrigerated meat ship, which is now on the regular service to the Antipodes. The system was developed by the Ship Lighting Department of the British Thomson-Houston Company. Fluorescent lighting would appear to have a promising future, though, to some extent, at the expense of the lamp capacity of the industry. A new development, announced in October by Siemens Electric Lamp and Supplies, Limited, is that of "gas-arc" lighting. This carries farther the war-time invention of the photographic flash tube, used in taking aerial photographs at night, the essential difference being that the intense light can now be emitted continuously as well as instantaneously. The light radiation is

produced by the conduction of electricity through the rare xenon gas at very high current densities. In the present stage of development, immediate commercial uses would seem to be in photography, for television and film-studio work, and in colour photography. Applications in wider spheres of internal and external lighting cannot yet be assessed.

During the past few months, some information has become available concerning foreign industries. In the British and American zones of Germany, a shortage of labour and a lack of wolfram wire are limiting lamp production to about 15 millions a year, compared with 150 millions before the war. Japanese production is estimated at between four and five millions a month, but still falls far short of current demand. An acute shortage of electric lamps is reported in France, although production during 1947 was estimated at about 55 millions. Lamps are being imported from Belgium, Czechoslovakia and the United States. In the United States, considerable publicity is being given to the National Electrical Manufacturers' Association's attempt to increase sales, on the ground that "Good lighting pays dividends in increased production, better worker psychology, health, greater safety, and is also a potent sales tool." Examples were given of increases in output from 25 to 50 per cent., due, it was claimed, to better illumination. Market surveys and demand estimates suggest that the industry is expecting a 100*l.* million market in annual lamp renewals, compared with 24*l.* million in 1946.

Telephone and telegraph manufacturers have been handicapped by shortages of labour and materials. They complain that the irregular flow of materials, and the need to find substitutes for scarce materials, have had an adverse effect on costs. Exports during 1947 totalled 6·7*l.* million, compared with 4·9*l.* million in 1946 and 2·9*l.* million in 1939. Demand greatly exceeds supply, and there does not appear to be any sign of a falling-off in the demand from overseas. The decision to limit telephone installations in the home market should lead, therefore, to a substantial increase in exports, and the target of 650,000*l.* a month by the end of 1948 should be reached without any great difficulty.

Refrigerator production (see Table II) increased, during 1947 from a monthly average of 675,000*l.* in the first quarter to 1·1*l.* million in the last quarter. Exports for the year totalled just over 2*l.* million, compared with 396,000*l.* in 1938, and a substantial further increase is expected, although competition from the United States is likely to grow more acute during the current year. The British Refrigeration Association, with a membership of 300 firms, state that order books are very full. Orders on hand from the Far East, for example, when the war ended with Japan, were valued at more than 10*l.* million; they included 28,000 refrigerators of 5 cub. ft. to 100 cub. ft. capacity and 64,000 air-conditioning plants, in addition to large quantities of ice-making and cold-storage plant and mobile refrigerating units.

The production of electric irons, electric fires and other electric household appliances decreased substantially during the past year, due mainly to a fall in the home demand following the increase in the purchase tax. Manufacturers are making great efforts to increase export sales, but are handicapped by import taxes and restrictions; for example, Morphy Richards, Limited, assemble in New Zealand, Australia and Argentina, where the sales of heat-controlled irons have been very satisfactory. The output of vacuum cleaners continued to increase. During the third quarter of 1947, production averaged 76,000 a month, compared with 35,000 in 1935. The vacuum cleaner produced by Hoover, Limited, remains one of the few items among domestic appliances selling at pre-war prices, plus purchase tax.

An important section of the light electrical engineering industry is that which produces accumulators and batteries. Output (see Table II) increased during the past year, averaging 1·3*l.* million a month for accumulators. Output of dry-cell batteries averaged 88·8 million cells a month during the last quarter of 1946, but fell during the first quarter of last year. The labour engaged on accumulator production totals just over 6,000, being approximately the same as in 1935. Exports of accumulators averaged 240,000*l.* a month during 1947, compared with 48,000*l.* in 1938, and exports of batteries averaged 41,500*l.* a month (13,000*l.* in 1938). Manufacturers have had to face difficult production problems since the end of the war. Mr. A. W. Browne, chairman of the Chloride Electrical Storage Company, Limited, one of the leading accumulator manufacturers, speaking at the annual meeting in July, reviewed the main factors in post-war demand, which so far greatly exceeds supply, mentioning in particular the demand for batteries from oil-field companies, for many special uses, one type being used for lowering down experimental boreholes to operate electronic recording apparatus. There is also a large demand from the National Coal Board and from foreign mining companies, particularly in Australia and Africa, for haulage and lighting purposes in mines.

The increasing use of battery-propelled vehicles for house-to-house deliveries is probably the chief source of demand, together with the demand for electric industrial trucks arising from the re-organisation and modernisation of factories. The belief that, in future years, the idea of using petrol road vehicles would be considered out of date, and that the use of battery-electric vehicles would be general, was expressed by Lord Brabazon, chairman of the British Electrical Development Association, at a luncheon held by the Electric Vehicle Association in June, 1947. He considered, however, that further progress was being delayed by the lack of suitable batteries, the design of storage batteries having remained practically unaltered for 40 years. The President of the Association, Sir Felix Pole, advocated the standardisation and interchangeability of batteries, and the chairman, Mr. A. W. Barnham, said that the time was almost in sight when a light-weight battery and a light body would make available a vehicle capable of a range of 60 to 80 miles a day. There has been a large increase in the registrations of electric vehicles, which totalled 2,285 during the first ten months of 1947, compared with 1,415 in 1946 and 867 in 1938. The growing importance of the electric-vehicle industry was indicated by the entry of the Austin Motor Company into this field. The company now holds half the shares of Austin Crompton Parkinson Electric

TABLE IV.—*U.K. Exports of Light Electrical Goods and Apparatus (Value, £1,000).*

	1938.	1946.	1947.
Wireless apparatus:			
Domestic radio receiving sets, complete and chassis substantially assembled (including radiograms in 1947)	441	3,318	4,600
Transmitting Apparatus	341	1,079	1,434
Valves, complete	495	1,776	1,501
Telegraph and telephone apparatus	2,913	4,962	6,718
Electric lighting appliances, accessories and fittings, and parts thereof, not elsewhere specified:			
Bulbs, complete, ready for use	593	1,291	1,283
All other descriptions	583	2,056	3,228
Batteries, primary, complete	163	551	499
Accumulators, complete	584	1,527	2,311
Parts and accessories		560	571
Electrical cooking and heating appliances	368	1,271	2,676
Electrical instruments, including X-ray apparatus	590	2,561	3,857
Insulating materials, not elsewhere specified	232	1,236	1,299
Refrigerating machinery	396	1,133	2,006
Vacuum cleaners and parts	320	1,030	2,424
Other electrical goods and appliances	1,296	3,228	3,064
Total	9,315	27,579	37,466

TABLE V.—*U.K. Exports of Light Electrical Goods and Apparatus, Including Wire and Cables, by Country of Destination (Value, £1,000).*

Country.	1938.	1946.	1947.
Eire	453	1,208	2,053
Palestine	101	930	1,184
Union of South Africa	1,951	4,710	6,481
British India	1,485	4,616	6,738
British Malaya	394	960	1,696
Australia	2,368	2,416	2,554
New Zealand	1,155	1,653	2,475
Other British Countries	1,473	3,867	5,792
Sweden	179	822	1,560
Norway	155	1,021	1,669
Netherlands	264	998	1,128
Belgium	134	1,226	1,202
Portuguese East Africa	158	1,043	907
Iraq	66	392	847
Iran	196	706	957
China	49	475	834
United States	70	132	127
Brazil	134	369	893
Argentine Republic	545	834	1,346
Other Foreign Countries	1,723	8,010	6,965
Total	12,053	36,388	47,408

TABLE VI.—*U.K. Imports of Light Electrical Goods and Apparatus (Value, £1,000).*

	1938.	1946.	1947.
Wireless apparatus:			
Domestic radio receiving sets, complete and chassis substantially assembled (including radiograms in 1947)	122	103	28
Valves, complete	131	155	362
Telegraph and telephone apparatus	111	36	75
All other descriptions	574	4,159	310
Carbons, electric, complete:			
Furnace	49	64	456
Other	28	70	49
Electric lighting appliances, accessories and fittings and parts thereof not elsewhere specified:			
Bulbs, complete, ready for use	123	8	50
All other descriptions	464	17	87
Batteries, primary (complete, and parts other than carbons)	43	10	21
Other electrical instruments	385	84	204
Other electrical goods and apparatus	636	142	267
Refrigerating machinery	525	59	261
Total	3,191	4,907	2,150

TABLE VII.—*U.K. Imports of Light Electrical Goods and Apparatus by Countries (Value, £1,000).*

	1938.	1946.	1947.
From:			
Canada	67	4,113	567
Other British Countries	61	13	36
Switzerland	176	47	106
United States	935	599	1,066
Other Foreign Countries	1,917	264	523
Total	3,156	5,036	2,298

TABLE VIII.—INTERNATIONAL EXPORTS OF LIGHT ELECTRICAL EQUIPMENT, 1938 TO 1946 (VALUE, £1,000).

Country.	1938.	Per Cent.	1939.	Per Cent.	1940.	Per Cent.	1941.	Per Cent.	1942.	Per Cent.	1943.	Per Cent.	1944.	Per Cent.	1945.	Per Cent.	1946.	Per Cent.
United Kingdom*	9,315	25·0	7,428	19·6	7,972	21·3	7,515	16·6	7,812	13·7	7,413	9·2	8,672	9·9	9,242	14·7	27,579	35·2
France†	1,090	2·9	1,170	3·1	500	1·3	236	0·5	5,000	8·7	6,670	8·4	4,600	5·3	940	1·5	1,993	2·6
Germany‡	9,350	25·2	10,400	27·5	9,350	25·0	13,200	29·4	16,600	29·1	19,000	23·4	5,880§	6·8	—	—	—	—
Switzerland	1,070	2·9	970	2·5	1,070	2·8	1,050	2·3	1,590	2·7	2,200	2·7	1,190	1·3	1,060	1·7	1,942	2·5
Sweden	1,640	4·4	1,900	5·0	1,400	3·7	1,900	4·2	1,540	2·7	1,480	1·8	950	1·1	1,960	3·1	4,435	5·7
United States	13,800	37·1	15,100	40·0	16,500	44·1	20,700	45·1	19,300	33·7	35,400	43·8	51,700	59·1	37,200	59·2	38,600	49·4
Canada	940	2·5	870	2·3	675	1·8	860	1·9	5,350	9·4	8,730	10·7	14,300	16·5	12,400	19·8	3,614	4·6
Totals	37,205	100·0	37,838	100·0	37,467	100·0	45,461	100·0	57,192	100·0	80,893	100·0	87,292	100·0	62,802	100·0	78,163	100·0

* Excluding electric vacuum cleaners and other portable mechanical appliances.
† Exchange rate for the war years estimated to be Fr. 176·6 to £, which rate was in force in the French Empire not under occupation.
‡ Exchange rate for the war years estimated to be RM. 10·05 to the £, on the then existing rate of 172·5 Swiss francs to RM. 100.
§ First six months only.

Vehicles, Limited (formerly the Associated Electric Vehicle Manufacturers, Limited), Crompton Parkinson holding the other half.

Trade statistics relating to the exports of light electrical goods and apparatus are given in Tables IV and V, opposite, as given in the *Trade and Navigation Returns* for December, 1947. Table IV shows exports, by main classes, for 1938, 1946 and 1947. Altogether, exports totalled 37·5*l.* million, compared with 9·3*l.* million in 1938. The monthly average of exports for 1947 was 3·1*l.* million. Assuming that this figure is broadly comparable with those given by Sir Stafford Cripps (excluding electrical machinery and cables), the target figure for mid-1948 is 3·63*l.* million, and, for the end of the year, 3·74*l.* million. The most important item in Table III, page 269, is telegraph and telephone apparatus, which accounted for 18 per cent. of the total; radio receiving sets and electric bulb and lighting appliances each accounted for 12 per cent.

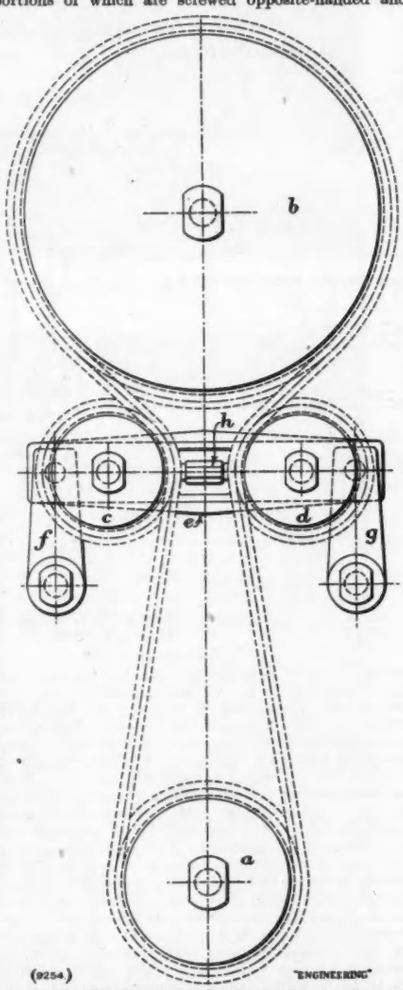
Table V shows the destination of exports (including cables). The best customers were British India and the Union of South Africa, each accounting for about 14 per cent. of the total. Australia, the best pre-war customer, was third with about 5 per cent., followed by New Zealand, Eire and British Malaya. Exports to hard-currency countries, including Canada and the Union of South Africa, totalled 13·2*l.* million, compared with 3·3*l.* million to the same countries in 1938. The percentage of the total accounted for by these exports, however, was the same in both years: 25·3 per cent. There does not appear, therefore, to have been any re-orientation of exports to hard-currency countries.

Imports of light electrical goods and apparatus are given in Table VI, opposite, by main classes and in Table VII, on the same page, by countries of origin; both are taken from the *Trade and Navigation Returns* for December, 1947. Imports were small, totalling 2·15*l.* million in 1947, compared with 3·19*l.* million in 1938, the main item being furnace carbons and complete valves. The United States and Canada were the principal suppliers. Table VIII, opposite, shows the value of the exports of principal manufacturing countries from 1938 to 1946, as given by the Board of Trade. In 1946, the United States led the field with 49·4 per cent. of the total, followed by the United Kingdom, with 35·2 per cent. Sweden and Canada accounted for 5·7 and 4·6 per cent., respectively. The relative importance of Britain increased from 14·7 per cent. in 1945 to 35·2 per cent., while that of the United States declined from 59·2 per cent. to 49·4 per cent. and that of Canada from 19·8 per cent. to 4·6 per cent. In 1938, Germany accounted for just over a quarter of the total. The American industry reported the highest sales, both in value and volume, in the history of the industry, and was expecting even greater sales in 1947. The production of electrical appliances, in all lines except refrigerators, was greater in 1947 than in any previous year. It is evident that the immense quantities of each item produced enable the American industry to quote low prices in foreign markets, and it is likely that competition will become intense during the coming months.

BRITISH EXHIBITION AT COPENHAGEN.—An exhibition of goods of British manufacture is being organised by the British Import Union of Copenhagen, in consultation with the Federation of British Industries, and with the approval of the British and Danish Governments. The exhibition will be held in Copenhagen from September 18 to October 3. It is intended that products of the engineering, chemical, building and associated industries shall be displayed in the Forum Building, the largest exhibition building in Copenhagen; textile and miscellaneous goods will be shown in the Tivoli Gardens; and transport, including motor cars and motor vehicles, n the Royal Riding House. It is hoped to arrange suitable sites on the outskirts of Copenhagen for the display and demonstration of British aircraft, and of agricultural and road-making machinery. Further information is obtainable from the British Import Union, Copenhagen, or from the London office of the Exhibition, Earl's Court Exhibition Building, London, S.W.5. The manager, on the British side, is Mr. G. H. Meadmore, M.B.E., formerly secretary of the British Industries Fair, and, on the Danish side, Mr. C. J. Marhauer.

CHAIN-DRIVE PHASE ADJUSTER.

A SIMPLE method of obtaining angular adjustment between two chain-driven sprocket wheels has been introduced by the Renold and Coventry Chain Company, Limited, of Didsbury, Manchester. The device is known as the chain phase adjuster and is illustrated in the diagrammatic sketch below, which shows how it may be applied to the camshaft drive of an automobile engine. The drive to the camshaft is transmitted from the crankshaft through two sprocket wheels and a chain in the usual manner, the crankshaft and camshaft sprockets being lettered *a* and *b* respectively in the illustration. The phase adjuster is located between these two sprockets and comprises two jockey sprockets *c* and *d*, which are fitted to a common bracket *e*. The bracket is supported at each end on the extremities of the two swinging arms *f* and *g*, and the complete unit is set so that when the two arms are vertical, the jockey sprockets are equidistant from the centre line between the camshaft and crankshaft sprocket wheels. The tension of the chain is adjusted by the double-ended hexagon screw *h*, the threaded portions of which are screwed opposite-handed and



(9254) "ENGINEERING"

enter suitably threaded holes in the bearing housings for the jockey sprockets, so that turning the hexagon causes the sprockets either to approach or recede from each other.

In operation, the bracket *e* is moved bodily by a screw gear inter-connected with the pivots of the swinging arms, but not shown in the illustration. This causes both arms to swing in the same direction with the result that the bracket is displaced either to the right or the left, according to the direction in which the arms swing. This has the effect of increasing the chain lap on one sprocket and decreasing the lap on the other; at the same time, the camshaft wheel is displaced angularly with respect to the crankshaft, the tension in the chain being entirely unaffected. It will be seen, therefore, that if the basic setting of the camshaft timing is arranged so that the jockey sprockets are symmetrically disposed about the drive centre line, movement of the bracket will either advance or retard the camshaft sprocket wheel with respect to the crankshaft.

The design described above refers to a two-wheel drive in which there is only one driven wheel, but other arrangements using two driven wheels and having either combined or independent angular displacement with respect to the driving sprocket, can be designed. Furthermore, although reference has been made solely to driving camshafts, the device obviously has many other applications.

LAUNCHES AND TRIAL TRIPS.

M.S. "BOGESUND."—Single-screw cargo vessel, built by the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, Co. Durham, to the order of Messrs. Rederi A/B Svea, Stockholm. Main dimensions: 284 ft. by 39 ft. by 22 ft. 11 in. to shelter deck; deadweight capacity, about 1,800 tons on a draught of 15 ft. 3 in. Six-cylinder two-stroke single-acting Flat Diesel engine of 1,350 brake horse-power, installed by Messrs. Richardsons, Westgarth and Company, Limited, West Hartlepool, Wallsend-on-Tyne, to give a trial speed of 13½ knots. Launch, February 24.

M.S. "BRITISH FAME."—Single-screw tanker built and engined by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Wallsend Shipyard, Wallsend-on-Tyne, for the British Tanker Company, Limited, Finsbury-circus, London, E.C.2. Accommodation can be adapted to suit either a European or an Indian crew. Main dimensions, 547 ft. by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, 15,875 tons on a draught of 30 ft. Six-cylinder combined-stroke opposed-piston Swan Hunter-Doxford oil engine to develop 6,400 brake horse-power and providing a service speed of 13¾ knots. Launch, February 25.

S.S. "IRISH ROSE."—Single-screw cargo vessel, with accommodation for 12 passengers, built and engined by Messrs. William Gray and Company, Limited, West Hartlepool, for Messrs. Irish Shipping, Limited, Westmoriand-street, Dublin, for service between Irish ports and the Baltic and Mediterranean. Main dimensions: 280 ft. by 44 ft. by 25 ft. 6 in. to shelter deck; deadweight capacity, about 2,050 tons on a draught of 19 ft. Triple-expansion engines constructed by the builders' Central Marine Engine Works to give a service speed of 12 knots. Launch, February 25.

S.S. "DJEBEL-DIRA."—Single-screw vessel for the carriage of general cargoes and sheep, with accommodation for 40 passengers, built by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Neptune Yard, Newcastle-upon-Tyne 6, for the Compagnie de Navigation Mixte, Marseilles. Main dimensions: 345 ft. by 51 ft. by 27 ft. 10 in.; deadweight capacity, 3,330 tons on a mean draught of 22 ft. 2 in. Parsons' marine steam turbines with double-reduction double-helical gearing, to provide a service speed of 15 knots, installed by the builders. Launch, February 25.

M.S. "KAITOKE."—Single-screw vessel for refrigerated and general cargoes, built and engined by Messrs. Alexander Stephen and Sons, Limited, Linthouse, Glasgow, S.W.1, for the Union Steam Ship Company of New Zealand, Limited, Wellington. Main dimensions: 325 ft. by 50 ft. by 26 ft.; gross tonnage, 3,550. Six-cylinder Stephen-Sulzer Diesel engine of 3,000 brake horse-power, designed to give a sea speed, fully loaded, of 12 knots. Launch, February 27.

M.S. "SOUTHBANK."—Single-screw cargo vessel, built and engined by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, to the order of the Bank Line, Limited (Messrs. Andrew Weir and Company), Bury-street, London, E.C.3. Main dimensions: 464 ft. 3 in. by 60 ft. by 29 ft. 3 in.; deadweight capacity, about 9,320 tons. Five-cylinder opposed-piston Doxford oil engine, to give a service speed of 14 knots. Trial trip, March 3.

M.S. "MERCIAN."—Twin-screw cargo vessel, strengthened against ice, built by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Wallsend-on-Tyne, for the Portuguese trade of Messrs. Ellerman Lines, Limited, Leadenhall-street, London, E.C.3. Main dimensions: 255 ft. by 42 ft. by 25 ft. to shelter deck; deadweight capacity, 1,740 tons on a draught of 17 ft. Two sets of six-cylinder two-cycle single-acting Polar marine Diesel engines of 1,920 aggregate brake horse-power, supplied by Messrs. Atlas Diesel Company, Limited, Beresford-avenue, Wembley, Middlesex, and constructed by Messrs. British Polar Engines, Limited, Govan, Glasgow. Service speed, 12½ knots. Trial trip, March 3.

S.S. "KARANJA."—Twin-screw liner to carry 240 first and second class passengers, 1,400 other passengers from India and Pakistan, together with general cargo. Built and engined by Messrs. Alexander Stephen and Sons, Limited, Linthouse, Glasgow, S.W.1, for the British India Steam Navigation Company, Limited, Leadenhall-street, London, E.C.3. Main dimensions: 480 ft. by 66 ft. by 41 ft.; gross tonnage, 10,300. Two sets of single-reduction geared turbines of 9,000 aggregate shaft horse-power, with three oil-burning boilers, designed to give a trial speed of about 18½ knots. Launch, March 10.

MODIFIED 4-6-0 LOCOMOTIVES; LONDON MIDLAND REGION.

MR. H. G. IVATT, M.I.MECH.E., CHIEF MECHANICAL ENGINEER.

Fig. 1.

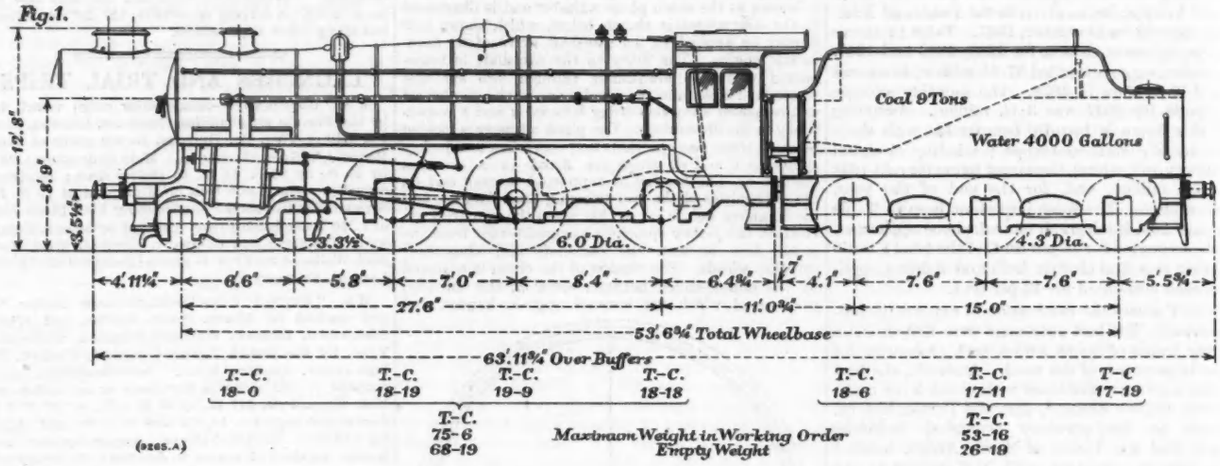
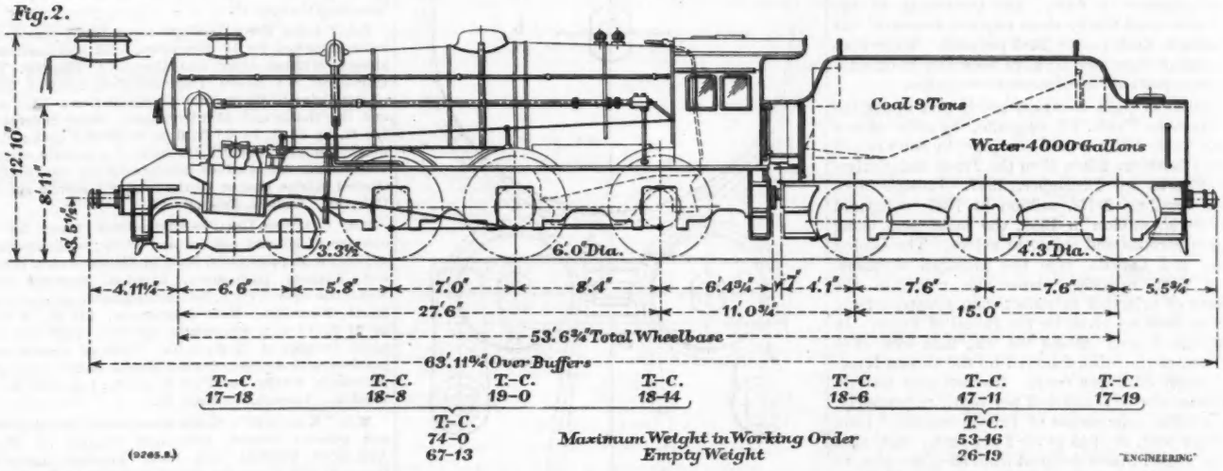


Fig. 2.



LOCOMOTIVE VALVE GEARS AND BEARINGS; BRITISH RAILWAYS (LONDON MIDLAND REGION).

AMONG the locomotives we were able to examine during a recent visit to Crewe were three experimental versions of the standard Class 5, 4-6-0 mixed-traffic engine of the London Midland Region. One was fitted with Timken roller bearings on the axles, the second had British Caprotti valve gear and Timken bearings, and the third had outside Stephenson's link motion and Timken bearings. Before describing the designs, it may be useful to recall the principal features of the standard locomotives, which were designed by Sir William Stanier, F.R.S., and, with a total of 732 in use, constitute one of the largest classes of mixed-traffic engines in this country.

The standard Class 5 locomotives have two outside cylinders, 18½ in. in diameter and 28 in. stroke, with Walschaerts gear and piston valves. The coupled wheels are 6 ft. in diameter and have plain bearings. The taper boiler works at a pressure of 225 lb. per square inch; the length of the barrel is 13 ft. 3⅜ in., and the outside diameter is 4 ft. 11⅛ in. at the front and 5 ft. 8⅛ in. at the firebox end. There are 151 small tubes, 1¾ in. outside diameter and 11 s.w.g. thick; 28 superheater-flue tubes, 5⅛ in. outside diameter and 7 s.w.g. thick; and 28 superheater elements, 1¼ in. outside diameter and 11 s.w.g. thick. The heating surfaces are 1,479 sq. ft. for the tubes, 171 sq. ft. for the firebox, and 348 sq. ft. for the superheater. The grate area is 28·65 sq. ft., and the distance between the tube plates is 13 ft. 2⅞ in. The tractive effort, at 85 per cent. of the boiler pressure, is 25,455 lb., and the adhesion factor is 4·77.

The experimental types are being built to the designs of the chief mechanical engineer, Mr. H. G. Ivatt, M.I.Mech.E., to determine the advantages of Timken bearings, poppet-valve gear, and Stephenson's gear, in increasing the availability of the locomotives and the mileage between shop repairs, and in reducing the cost of maintenance and the work entailed in the running sheds. The saving in fuel due to the lower friction of roller bearings can be only slight; the main object in using them is to reduce the troubles associated with plain axleboxes. Caprotti valve gear is completely enclosed in an oil bath, and although it has been used extensively overseas, notably in India and the Federated Malay States, it has not received much attention in this country. It is true that ten ex-L.N.W.R. "Claughton" Class 4-6-0 locomotives were fitted with Caprotti valve gear by the L.M.S. Railway before the recent war, but in the latest application the modifications to suit the gear are more thorough. The experimental locomotives built, or now under construction, are ten, Nos. 4738 to 4747, with Caprotti gear and plain axleboxes; ten, Nos. 4748 to 4757, with Caprotti gear and Timken roller bearings; nine Nos. 4758 to 4766, standard locomotives with Walschaerts gear, but with Timken bearings; and one, No. 4767, with Stephenson's link motion, piston valves, and Timken bearings. Records of costs, etc., of all these locomotives will be maintained, and will be compared with the records of a number of standard Class 5 engines which are also being built at about the same time. In this way, it is hoped to arrive at a true estimate of the relative merits of the modifications.

One of the nine locomotives to be built, which are standard except for the provision of Timken taper-roller bearings to all engine and tender axles, is illustrated in Fig. 5, on page 276, and an outline drawing, showing the principal dimensions, is reproduced in Fig. 1, on this page. The roller bearings for the coupled wheels are housed in cannon-type axleboxes, which are split on the horizontal plane to allow them to be assembled on the axle after the cones and wheels have been pressed on. Manganese-steel liners are welded to the axlebox faces, and flanges for bearing on the hornblocks are provided only on the inside edges—an arrangement made possible by the use of cannon-type axleboxes. One-piece hornblocks are riveted to the leading and intermediate horns, but separate axlebox guides had to be used for the trailing horns, to avoid fouling the firebox. Manganese-steel liners are bolted to the hornblock and guide faces, and similar liners are fitted to the axlebox and horn faces of the standard locomotives with plain bearings. The bogie and tender axles are fitted with similar separate axleboxes, the casings of which may be removed by taking out the bearing bolts in the usual way, thus permitting the bearings to be inspected. The roller bearings are lubricated with oil. The horns for roller bearings are wider than those for plain bearings; the hornblocks are consequently wider, and it has therefore been necessary to lengthen the wheelbase by increasing the distance between the intermediate and trailing wheels from 8 ft. to 8 ft. 4 in. The provision of roller bearings has increased the weights (in working order) from 72 tons 2 cwt. to 75 tons 6 cwt. for the engine, and from 53 tons 13 cwt. to 53 tons 16 cwt. for the tender—a total increase of 3 tons 7 cwt. The factor of adhesion has been changed from 4·77 to 5·04. The boiler, cylinders, valve gear, etc., are substantially the same as those of the standard Class 5 locomotive, the principal data of which have already been recalled. Three of the nine engines are to be built with double chimneys and electric lighting. The turbo-generator and equipment for the latter are being supplied by Messrs. J. Stone and Company, Limited, Deptford, London, S.E.14.

One of the ten Class 5 locomotives which are to be fitted with Caprotti valve gear and Timken roller bearings, is shown in Fig. 6, on page 276, and an outline drawing with the leading dimensions is reproduced in Fig. 2, on this page. As already stated, the Class 5 locomotives are also to be fitted with Caprotti valve gear and plain bearings. The cylinders have been completely redesigned to suit the valve gear. The steam inlet is on the outside of the cylinder, and the exhaust passages are on the inside, next to the main

VALVE GEARS FOR 4-6-0 LOCOMOTIVES.

MR. H. G. IVATT, M.I.MECH.E., CHIEF MECHANICAL ENGINEER.

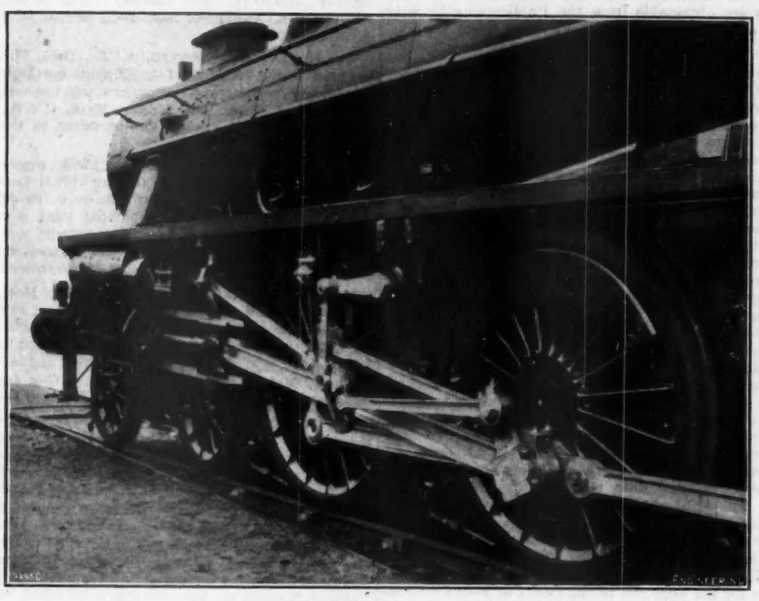


FIG. 3. OUTSIDE STEPHENSON-LINK MOTION.

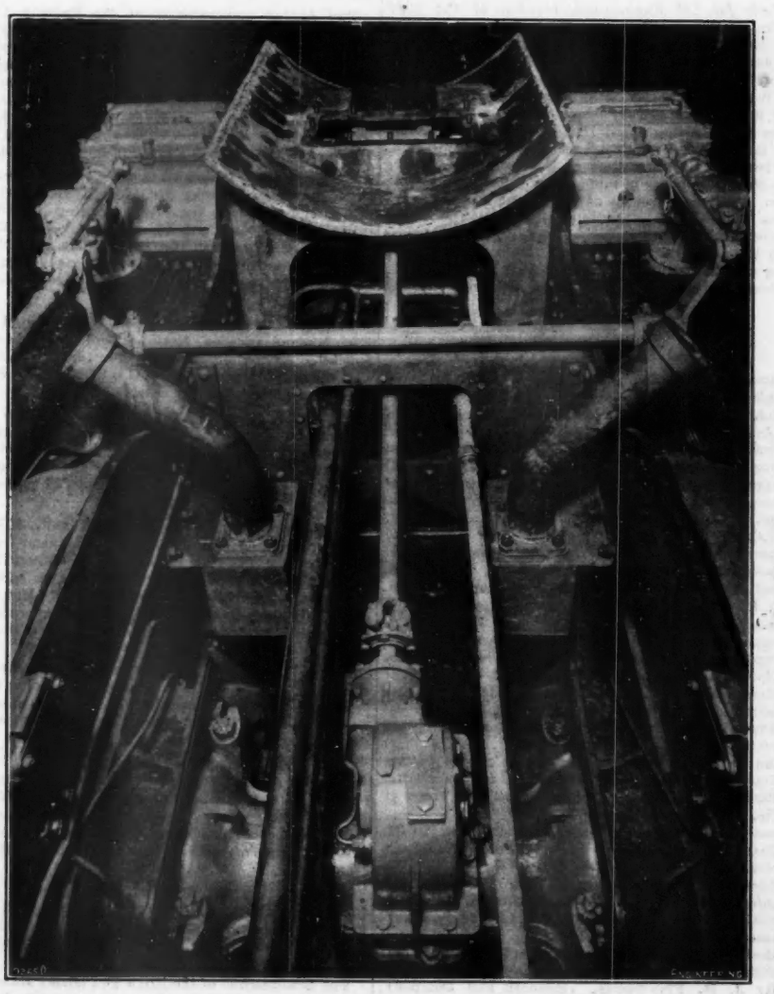


FIG. 4. DRIVE FOR CAPROTTI VALVE GEAR.

frames; this arrangement provides straighter passages than are usual with Caprotti valve gear. The cylinders were cast in steel at Crewe Works, and cast-iron liners have been pressed in. The cages and the poppet cam boxes have been supplied by Messrs. Associated Locomotive Equipment, Limited, Duke's-court, 32, Duke-street, St. James's, London, S.W.1.

The valves are seated by the pressure of steam which is taken directly from the regulator to the cylinders; therefore, when the engine is coasting, the poppet valves are free to drop off their seats, thus providing a large by-pass. The drive for the valve gear is taken from the intermediate coupled axle. In the case of engines with roller bearings, the gear housing is bolted to a flanged aperture on the top of the cannon-axlebox casing, as shown in Fig. 4. Where plain axleboxes are fitted, the drive consists of a cast housing, bearing on the axle, and containing a spur-wheel reduction drive to a pair of bevel wheels which rotate the cardan-type shaft. In both cases, this shaft, clearly shown in Fig. 4, is fitted with Hardy Spicer universal couplings to allow for the movement of the axle, and it drives the cam box on each cylinder by means of bevel gears mounted on the smokebox saddle, and two cross shafts, one to each cam box, which are fitted with universal couplings and splined joints. The drive from the axle to the cam boxes is expected to give long life and low oil consumption. In order to avoid confusing the driver, the reversing gear has been arranged so that the number of turns of the reversing screw required to change from full forward to full back gear, is the same as that for a conventional locomotive of similar class. The method of connecting the reversing screw and the cam boxes will be apparent from Figs. 4 and 6. A cross shaft with a lever at each end is connected to the reversing screw by a long tube, divided in the centre and rocking on an "idle" lever, and is connected to each cam box through a short link which operates a bevel-gear box; this box converts the reciprocating movement derived from the reversing screw into a rotary motion of the cam-box coupling. Care has been taken in the design to facilitate maintenance work; in particular, the valves can be readily inspected by unbolting the cam box and sliding it out laterally, thus exposing the valves and the valve seats in the cylinders. It will be observed from Fig. 2, that not only has the wheelbase been lengthened by 4 in. to accommodate the roller bearings, but also the boiler has been raised 2 in. to provide room for the valve drive in the region of the smokebox saddle. The total weight of the locomotive and tender in working order is 127 tons 16 cwt.; the separate weights and axle loads are given in Fig. 2. This is 2 tons 1 cwt. heavier than the standard Class 5 locomotive, but it is 1 ton 6 cwt. lighter than the standard engine with roller bearings. The factor of adhesion is 4·94. Three of the engines with Caprotti gear are being built with double chimneys, steam-operated cylinder cocks and Stone's electric lighting.

The Class 5 locomotive with outside Stephenson link motion is shown in Fig. 7, on page 276, and a closer view of the motion is given in Fig. 3, on this page. The engine has piston valves and roller bearings, and is otherwise generally similar to the standard Class 5 locomotives. The particular feature of Stephenson link motion which justifies this experiment is its characteristic of increasing the lead imparted to the valves at short cut-off. At low speeds, when an engine is working at long cut-off, excessive lead is undesirable; but at high speeds, when a short cut-off is used, a comparatively large lead is required to allow the maximum quantity of steam to enter the cylinders. With Walschaerts gear, the valve lead remains practically constant at all values of the cut-off. Double return cranks, in place of the conventional eccentrics, have been fitted to the locomotive. The full-gear valve travel is the same as that on the standard engines with Walschaerts gear, but the variable-lead characteristic of the Stephenson gear has been arranged to give increased steam-port openings at the shorter cut-offs. The link motion has been applied to the locomotive with little structural alteration. The motion girder used with Walschaerts valve gear in the original engines, as shown in Fig. 5, has been dispensed with, the reversing cross shaft and brackets are as before, and two hanging links on brackets support the link which connects the die block to the standard valve-spindle crosshead. The last previous application of outside Stephenson gear to a main-line locomotive in this country is understood to have been that on William Dean's G.W.R. single-driver locomotive, built in 1884. As will be seen from Fig. 7, the locomotive is provided with a double chimney; it is also fitted with Stone's electric lighting. At the time the photographs reproduced on page 276 were taken, no decision had been reached regarding the method of lettering the locomotives of British Railways. In Figs. 5 and 7, the lettering shows no change from pre-nationalisation days, but in Fig. 6 the tender is painted with an experimental version of "British Railways," and a letter "M," which prefixes the number of the engine, indicates "London Midland Region."

BRITISH ELECTRICITY AUTHORITY.

SEVERAL appointments have been made in the Transmission and Generation Divisions at the head office of the British Electricity Authority, Portland Court, 170A, Great Portland-street, London, W.1. Mr. P. J. Squire, B.Sc., D.F.H., previously chief assistant operation engineer, head office, Central Electricity Board, has been appointed system operation engineer to the Authority. Mr. F. J. Lane, M.Sc., M.I.E.E., hitherto chief of the system development section, Central Electricity Board, becomes transmission design engineer, and Mr. F. Shakeshaft, A.M.I.E.E., formerly power-station development engineer to the Board, generation design engineer to the Authority. Mr. C. E. H. Verity, O.B.E., M.I.C.E., M.I.Mech.E., M.I.E.E., hitherto chief development and testing engineer, mechanical engineering, London Power Company, is now generation construction engineer to the Authority, and Mr. J. A. Vice, A.M.I.E.E., formerly technical adviser, generation, County of London Electric Supply Company, has taken up the appointment of generation operation engineer to the Authority.

Appointments in the generating divisions of the Authority include those of a number of chief generation engineers (operation) and chief generation engineers (construction). In the London Division, Mr. H. J. Bennett, A.M.I.E.E., has been appointed to the position (operation). In the South-Eastern Division, the appointments have been made to Mr. P. Briggs (operation), and to Mr. W. B. Shannon, M.I.C.E. (construction); in the Eastern Division to Mr. A. C. Thirtle, A.M.I.E.E., A.M.I.C.E. (operation) and to Mr. T. Yule, M.Eng., M.I.Mech.E., A.M.I.C.E. (construction); in the East Midlands Division to Mr. P. Ormiston, A.M.I.E.E. (operation) and to Mr. F. Favell, M.I.E.E., M.I.Mech.E. (construction); in the Midlands Division to Mr. G. P. Sutton, A.M.I.E.E. (operation) and to Mr. L. F. Jeffrey, B.Sc., M.I.E.E., M.I.C.E., M.I.Mech.E. (construction); and in the North-Western Division to Mr. J. L. Ashworth, A.M.I.E.E., A.M.I.Mech.E. (operation) and to Mr. C. R. Watson-Smyth (construction). Mr. E. H. Jones, M.I.Mech.E., A.M.I.E.E., and Mr. J. B. Jackson, A.M.I.E.E., A.M.I.Mech.E., have been appointed chief generation engineers (operation) in the South Wales and North Eastern Divisions, respectively.

THE NICKEL BULLETIN.—The first number of volume 21 of *The Nickel Bulletin*, dated January, 1948, has recently been issued. The format is new, the columns being slightly wider and space being saved by reducing and rearranging the headings to the various main sections. The matter is now set in "Times Roman" type. Much of the publication is still devoted to abstracts of published work on nickel and its alloys, but the pre-war practice of including other articles of general metallurgical interest has been restored. The *Bulletin* is obtainable gratis on application to the Mond Nickel Company, Limited, Grosvenor House, Park-lane, London, W.1.

DIESEL LOCOMOTIVE MAINTENANCE.—It is evident, from an article in the *Railway Age* of February 21, entitled "Diesel Maintenance Policy is Becoming a Major Issue," that the cost of maintaining Diesel locomotives in the United States is causing some concern. After explaining that, whereas with a steam locomotive parts are generally inspected, removed, repaired and replaced, the parts of a Diesel locomotive are usually inspected, removed if defective, and replaced with new parts, the writer states that managers must decide whether to buy the Diesel parts from the locomotive builders or their authorised suppliers, thus ensuring appropriate standards of accuracy, etc. or to make them in their own workshops, thus encouraging competitive prices and ensuring a dependable supply under their own control.

MERCHANT NAVY SCHOLARSHIPS.—Scholarships under the Drewry Fund for boys wishing to become deck officers in the Merchant Navy will again be awarded this year to the sons of Merchant Navy, R.N., R.N.R., and R.N.V.R., officers and ratings who died, or who were seriously disabled, by enemy action. The sons of officers who were discharged on grounds of ill-health while serving in the war or who are still serving, are also eligible. The scholarships are tenable at the Nautical College, Pangbourne; at H.M.S. Conway, H.M.S. Worcester and the T.S. Mercury; and at the School of Navigation, University College, Southampton. Candidates for entry into the Nautical College, Pangbourne, and the T.S. Mercury must be 13 or 14 years of age, those for entry into H.M.SS. Conway and Worcester 14 or 15 years of age, and candidates for the University College, Southampton, must be 16 years of age. Inquiries should be addressed, in the first instance, to the secretary of the Drewry Fund, Ministry of Transport, Berkeley Square House, London, W.1. Intending candidates should note, however, that the final date for the submission of completed applications for awards commencing in the autumn of 1948 is April 30.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Electrical Machines.—The Codes of Practice Committee for Civil Engineering, Public Works and Building have issued a draft code relating to the installation and maintenance of electrical machines, including transformers, rectifiers, capacitators, and associated equipment. The code, No. 321.102, covers equipment operating at 650 volts, or less, and installed on the consumer's side of the electricity-supply intake. A list of materials, appliances and components is given, together with the relevant British Standard Specifications to which they should conform. Information on the protection of apparatus, circuits, and conductors against conditions involving risk of fire, explosion and damage from dusty, damp or corrosive atmospheres, is included. Methods of protecting motors and motor circuits against excess current are referred to, and advice is given on starting-current considerations, the grouping of fractional horse-power motors, the protection of capacitor circuits and methods of control where capacitors are directly connected to the network. Recommendations regarding the efficient control, namely, the starting, stopping and adjustment during running of various types of motors, are made. Other useful information is contained in the section headed "Work on the Site" and data regarding the most suitable types and sizes of cables for motors working under various conditions are given in appendices. Comments received up till April 1 will be examined by the Code and Drafting Committee. The final draft will be submitted by the Engineering Services Sectional Committee for the approval of the Codes of Practice Committee. [The price of copies of the draft code, reference C P (B) 718, is 2*s.*, postage included.]

Fuels for Oil Engines.—A revision of the 1937 edition of B.S. No. 209, covering fuels for oil engines, has been issued. It deals with petroleum and shale oils and permits the use of additives, but does not yet cover fuel oils derived from coal owing to the lack of the requisite technical data. Two classes of fuel are now specified in detail; they correspond closely to those called "High-Speed Diesel Fuel" and "Marine and Industrial Diesel Fuel," in the 1937 specification. Guidance is given to users of the fuels upon points that should be borne in mind when ordering and using them. Full descriptions of the methods of test are given. These include the determination of the cetane number, the viscosity, carbon residue, the recovery from distillation at 350 deg. C., the flash point, the gross calorific value, and the contents of water, ash, sediment and sulphur. [Price 7*s.* 6*d.*, postage included.]

BOOKS RECEIVED.

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 2. *Planning a New Area.* By DR. K. LEHMANN. [Price 9*d.* net.] Appendix No. 12. *Modern Machines for Coal Extraction.* By BERGASSESSOR FRITZ LANGE. [Price 1*s.* net.] H.M. Stationery Office, Kingsway, London, W.C.2.

Department of Scientific and Industrial Research. Food Investigation. Special Report No. 50. *Aluminium and Aluminium Alloys in the Food Industry.* By DR. J. M. BRYAN. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* net.]

Liverpool Observatory and Tidal Institute. Annual Report, 1947. The Director, Liverpool Observatory and Tidal Institute, Liverpool.

Annuaire pour l'An 1948. Issued by le Bureau des Longitudes. Gauthier-Villars, 55, quai des Grands-Augustins, Paris (VIe). [Price 550 francs, in paper covers.]

Cours de Mécanique. By PROFESSOR HENRY FAVRE. Volume I. Statique. Dunod, 92 rue Bonaparte, Paris (VIe). [Price 980 francs.] Leemann Frères et Cie, Stockerstrasse 64, Zürich, 2.

Steam-Engine Builders of Norfolk. By RONALD H. CLARK. The Augustine Steward Press, Tombland, Norwich. [Price 5*s.* 6*d.*]

Palmer's Private Companies. Their Formation and Advantages. By DR. J. CHARLESWORTH. Fortieth edition. Stevens and Sons, Limited, 119-120, Chancery-lane, London, W.C.2. [Price 3*s.*]

"Mechanical World" Monographs. No. 39. *Flow Through Standard Nozzles, Orifice Plates and Venturi Tubes.* By J. R. FINNIECOME. Emmott and Company, Limited, 31, King-street West, Manchester, 3. [Price 3*s.* net.]

PERSONAL.

MR. E. AUBREY LLOYD has been elected chairman of the General Council of British Shipping, 3-6, Bury Court, St. Mary Axe, London, E.C.3, in succession to SIR ERNEST MURRANT. SIR GEORGE CHRISTOPHER and MR. COLIN S. ANDERSON have been elected joint vice-chairmen.

MR. H. B. ROBIN ROWELL, A.F.C., D.L., M.I.N.A., has been elected President of the Shipbuilding Conference, in succession to SIR MURRAY STEPHEN, who has completed two years of office. MR. HENRY MAIN, C.B.E., J.P., M.I.N.A., has been elected vice-president of the Conference.

MR. J. W. BERRY, M.I.Mech.E., M.I.P.E., works director, Birmingham Aluminium Casting (1903) Company, Limited, Birmid Works, Dartmouth-road, Smethwick, 40, Staffordshire, has been appointed joint managing director with MR. E. PLAYER, the present managing director. MR. G. A. RIDER, commercial manager, has been appointed commercial director of the company.

MR. M. S. HATCHELL, assistant to the Chief Mechanical Engineer, British Railways, Southern Region, Brighton, has been appointed principal assistant (locomotives) to the Chief Mechanical Engineer, London Midland Region, Derby. MR. S. WILLIAMS, divisional signal and telegraph engineer, Manchester, has been made acting assistant signal and telegraph engineer, London Midland Region.

MR. J. R. EDWARDS, formerly responsible for the communications section, signal and telegraph engineer's department, L.M.S. Railway, has been appointed assistant, engineering (communications), Railway Executive Headquarters. MR. R. W. BAILEY, T.D., M.Eng., A.M.I.C.E., staff assistant to the chief engineer, L.M.S. Railway, Watford, has been made technical, workshop and maintenance-staff assistant to the chief officer (staff and establishment), Railway Executive Headquarters. MR. A. G. TINDILL, principal assistant (operating), L.N.E. Railway, Marylebone, has been appointed administrative assistant to the chief officer (motive power), Railway Executive Headquarters.

Two further appointments at the Railway Executive Headquarters are that of MR. J. S. CAMPBELL, M.I.Struct.E., formerly bridge and steelwork assistant to the Chief Engineer, L.M.S. Railway, to be assistant (engineering) for bridges, and that of MR. J. M. HARRISON, A.R.I.B.A., previously assistant to the Chief Engineer (architectural) and architect (Southern area), L.N.E. Railway, to be executive officer (architectural) and architect to the engineer's office (Eastern Region).

The board of Powell Duffryn Technical Services, Limited, announce that MR. W. L. BOON, O.B.E., M.I.Mech.E., has been appointed managing director (fuel utilisation) and MR. D. G. HEMMANT, B.Sc., M.I.Min.E., and MR. R. L. LECHMERE-OERTEL, B.Sc., M.I.Min.E., managing directors (mining). Mr. Hemmant is leader of a Powell Duffryn mission now on its way to Queensland to survey the coalfields there.

MR. R. RINGHAM, area general manager, No. 1 area, East Midland Division, National Coal Board, has been appointed production director of the Division in succession to MR. H. WATSON SMITH, C.B.E., M.I.C.E., F.G.S., who has relinquished the position.

MR. TOM MAKEMSON, M.B.E., has intimated his desire to the Council of the Manchester Association of Engineers, St. John-street Chambers, Deansgate, Manchester, 3, to relinquish his position as secretary of the Association during the next few months on account of pressure of other work.

MR. LEONARD ANDREWS, M.B.E., M.I.C.E., M.I.E.E., has transferred his office and testing equipment from his laboratory at: The Hut, West End-lane, Pinner, Middlesex, to The Hut Laboratory, Stapleford, near Salisbury, Wiltshire. (Telephone: Stapleford 258.) Here he is continuing his research work relating to the appraisement and control of fine-particle size distribution characteristics.

MR. R. L. R. SLACKE, for the past 12 years associated with Mr. Leonard Andrews in research relating to the recovery of low-ash content fine coal from discarded washery slurries, has been appointed coal preparation engineer for Shropshire and South Staffordshire under the National Coal Board.

MESSRS. A. A. JONES AND SHIPMAN, LIMITED, Narborough-road, South Leicester, have appointed MESSRS. KERRY'S (GREAT BRITAIN), LIMITED, Falcon-street, Ipswich, to be sole distributing agents for their small tools in the counties of Norfolk, Suffolk, Cambridgeshire and Huntingdon.

MESSRS. BRITISH ELECTRONIC PRODUCTS (1948), LIMITED, Moxley-road, Bilston, Staffordshire, have transferred their development, engineering and certain production departments to new premises at Brereton-road, Rugeley, Staffordshire.

The headquarters of the ROAD TRANSPORT EXECUTIVE are at St. Pancras Chambers, Euston-road, London, N.W.1. (Telephone: TERminus 7151.)

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Steel outputs have been well maintained in spite of the fact that three furnaces were laid off in the middle of last month. The third of the eight new furnaces under construction at Stewarts and Lloyds Mossend tubeworks was brought into production last week. The furnace has a designed capacity of about 1,000 tons a week. A fourth unit of a similar size is expected to be ready later in the year. A few small coasting vessels arrived at Grangemouth last week with about 1,500 tons of scrap from Southampton and Shoreham, while a further 5,000 tons arrived from Hamburg. Current steel production is sufficient to maintain a fairly satisfactory supply of semies for re-rollers and sheet-makers, but sheet bars are short of requirements. There is no reduction in the number of inquiries reaching Scotland from overseas buyers. Recent orders included several from Canada, while South African buyers have also been trying to place further business. Pig-iron production has been maintained satisfactorily. Some uneasiness has been expressed regarding the supply of refractory materials for blast furnaces and coke-ovens, but makers of these materials state that an acute shortage is unlikely.

Scottish Coal.—The more settled conditions which have returned to the Central West and Central East Areas following the solution of the recent problem at Priory Colliery have been reflected in an improvement of some 12,000 tons a week in outputs from the two zones. The total Scottish production in the first week of March, however, was only about 3,000 tons higher than in the preceding week. Apart from a strike at one pit in Ayrshire, the Division has been comparatively free from major labour troubles recently. The slight improvement in production in conjunction with lower consumption as a result of the higher outside temperatures has ensured adequate fuel supplies throughout the consumer range. Industrial users generally are comfortably placed for supplies, while domestic deliveries against basic allocations have been maintained fully. Any shortage in house-coal tonnages is made good from opencast production.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—During the past week, Gen. Sir Reade Godwin-Austen, chairman of the South Western Divisional Coal Board opened the most modern pithead baths in the country at the Penrikyber Colliery in the Aberdare Valley. The baths have cost 39,000*l.* to build and it was intended to add to them a canteen costing a further 10,000*l.* The baths can accommodate 1,344 men at the same time. Output from the South Wales mines has remained steady, and in the week ended March 6, the latest for which official figures are available, totalled 452,600 tons. Of this quantity, 16,875 tons were produced on the Saturday morning voluntary shift when only 61 out of more than 200 pits in the coalfield were at work. Deliveries to inland destinations have been on an active scale and have provided a ready outlet for almost the whole of current outputs. As a rule, bookings already in hand were sufficient to earmark potential outputs of the better sorts for some time to come. Nevertheless, a slight reduction in the inland programme has resulted in rather more coal becoming available for delivery to consumers in the foreign market. In spite of this, however, little coal was available for export, as allocations already made for the Argentine, France, Eire, Italy and Portugal and to coaling depots were sufficient to account for all the coal that could be spared. With the approach of warmer weather, exporters are hoping that inland requirements will be reduced and that more coal will be available for shipment abroad. The demand for cokes and patent fuel has been maintained and supplies are scarce.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, business in tin-plate was more active. Consumers were commencing to issue their requirements for the second quarter of the year and a satisfactory number of orders were placed. In the export market not much was done as makers had little to spare until the priority orders from home consumers had been booked. Steel sheets continue in keen demand, while iron and steel scrap is now needed urgently by all consumers.

THE LATE MR. A. H. BRIDGE.—We regret to record the death of Mr. Albert Henry Bridge, which occurred at Winchmore Hill, London, on Tuesday, March 9, at the age of 74. Mr. Bridge had been a member of the editorial staff of our contemporary the *Electrical Review* since 1891, and for many years occupied the position of commercial editor. He had thus acquired an encyclopædic knowledge of all branches of the electrical industry and his experience enabled him to deal judicially with the many controversial matters which arose during his term of office. He retired about ten years ago.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Full supplies of gas, restored after the recent strike of coke-men, have permitted full operation of all processes of steelmaking and fabrication, but the demand for steel is greater than the supply, owing, in part, to lack of sufficient materials and the inequitable operation of the system of allocations. Trouble is threatened among maintenance men, some thousands of whom, including engineers, fitters and electricians, threaten to abandon overtime working unless their demand for a 20 per cent. wage increase is conceded. The men complain that negotiations have been much too protracted. The ban of overtime would operate at Easter, when extensive maintenance work is done. Further evidence of the decline of the sellers' market has been forthcoming. Manufacturers have been advised that in some steel products, United States and Italian quotations were much lower than those from Sheffield and deliveries were promised at much earlier dates. Good progress is being made with the installation of machine tools for the re-equipment of works, but long delays in securing the delivery of light and heavy machine tools is still a common experience.

South Yorkshire Coal Trade.—Fuller production of deep-mined and opencast coal has provided much-needed supplies to replenish reserves at the works. It has been arranged to export 100,000 tons of Yorkshire coal during March and April to seven countries whose food and raw materials we urgently require; it will include steam and gas coal. More opencast coal is included in home allocations to provide for the drive for coal exports. Gas coke is in moderate supply, and blast-furnace coke production now practically satisfies requirements, but there is none to spare.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Outputs of Tees-side iron and steel-producing plants continue at a very high level and are still increasing, but the distributable tonnage is still considerably short of the urgent requirements of consumers. The pressure for maximum deliveries of most descriptions of material is unabated. The changes made in several branches of industry, however, are gratifying and a more hopeful tone generally pervades the market than has been the case for some time past. Considerable quantities of coke are now stored at the blast furnaces and the yield of Cleveland ironstone is increasing. Meanwhile, the well-maintained imports of high-grade foreign ore deal satisfactorily with the continued exceptionally heavy demand. The position as regards scrap, however, still occasions much anxiety. Foundry outputs are adversely affected by the scarcity and this is unfortunate since orders, both for home purposes and for export, are accumulating. Every effort is being made to collect greater quantities of scrap and the hope is expressed that supplies from the Continent may be on a fairly substantial scale in the near future.

Foundry and Basic Iron.—The dearth of foundry pig-iron, coupled with the great shortage of cast-iron scrap, continues to hamper seriously operations at foundries engaged in the manufacture of commodities in great demand. Nearly all the foundry pig for use on the North East coast has to be conveyed by rail from the Midlands, and the maintenance of regular and satisfactory deliveries is difficult. Basic-iron production suffices for the current actual needs of makers' own steel furnaces, but larger supplies would be acceptable.

Hematite, Low Phosphorus and Refined Iron.—Users of East-coast hematite are still unable to secure iron on a scale that would enable them to re-stock their empty storage yards, but they are receiving supplies sufficient to meet their present essential needs. Outputs of low- and medium-phosphorus qualities are steadily absorbed and available parcels of refined iron are readily taken up.

Manufactured Iron and Steel.—Semi-finished iron plants are busily occupied and the branches of works turning out finished iron commodities are as actively engaged as circumstances permit; steel producers have embarrassing heavy commitments. Some increase in the tonnage of steel semies reaching the re-rolling mills is reported, but the import of foreign products continues small and the slightly better supplies from home sources are moving promptly into consumption. The intense pressure for larger parcels of billets, blooms, slabs and sheet bars shows no signs of easing. The total make of the finished descriptions of steel is enormous, but the opinion prevails that peak production has not yet been achieved. The expanding output, however, does not keep pace with the huge and growing demand. Black and galvanised sheets, plates, angles, railway material and colliery and other, similar, equipment continue in extremely strong request.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, March 22, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Location of Underground Services," opened by Mr. J. W. Leach. *South Midland Centre:* Monday, March 22, 6 p.m., James Watt Institute, Birmingham. "Closed Cycle Control Systems," by Professor A. Tustin. *North-Eastern Centre:* Monday, March 22, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Centralised Ripple Control on High-Voltage Networks," by Messrs. T. W. Ross and R. M. A. Smith. *Mersey Centre:* Monday, March 22, 6.30 p.m., Philharmonic Hall, Hope-street, Liverpool. Faraday Lecture: "Electricity and Everyman," by Dr. P. Dunsheath. And at *North-Western Centre:* Wednesday, March 24, 7.30 p.m., College of Technology, Manchester. *East Midland Centre:* Tuesday, March 23, 6.30 p.m., Gas Department, Nottingham. "Protective Finishing of Electrical Equipment," by Messrs. F. Widnall and R. Newbound. *North Midland Centre:* Tuesday, March 23, 6.30 p.m., Electricity Department, Whitehall-road, Leeds. "Automatic Regulators and Servo Mechanisms," by Dr. J. C. Evans. *Scottish Centre:* Tuesday, March 23, 6.30 p.m., Royal Technical College, Glasgow. "Electricity Supply as a Consumer Service," by Mr. C. T. Melling. *Radio Section:* Wednesday, March 24, 5.30 p.m., Victoria-embankment, W.C.2. "Three-Dimensional Cathode-Ray-Tube Displays," by Messrs. E. Parker and P. R. Wallis.

INSTITUTE OF TRANSPORT.—Monday, March 22, 7 p.m., Town Hall, Reading. "Some Far Eastern Transport Problems," by Mr. L. C. F. Bellamy.

JUNIOR INSTITUTION OF ENGINEERS.—*Sheffield District:* Monday, March 22, 7.30 p.m., 198, West-street, Sheffield. "Light Alloys and Some Engineering Applications," by Mr. H. A. Wainwright.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Bournemouth Branch:* Monday, March 22, 7.45 p.m., Garvis Hall Restaurant, Arcade, Bournemouth. "Motor Control Gear," by Mr. R. F. Mathieson.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 23, 5.30 p.m., Great George-street, S.W.1. "L.M.S. Lawley Street Goods Depot, Birmingham," by Messrs. E. F. Ingall and E. Lancaster. *Newcastle-upon-Tyne Association:* Tuesday, March 23, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Recent Developments in Railway Engineering," by Mr. J. Taylor Thompson.

INSTITUTION OF MECHANICAL ENGINEERS.—*South Wales Branch:* Tuesday, March 23, 6 p.m., Mackworth Hotel, Swansea. "Corrosion of Heating Surfaces in Boiler Plants," by Messrs. J. R. Rylands and J. R. Jenkinson. *Institution:* Friday, April 2, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. In conjunction with *Applied Mechanics Group.* "Researches into the Deformation of Metals by Cold Rolling," by Dr. Hugh Ford. "Calculation of Roll Force and Torque in Cold Strip Rolling with Tensions," by Mr. D. R. Bland and Dr. Hugh Ford. AUTOMOBILE DIVISION. *Birmingham Centre:* Tuesday, March 23, 7 p.m., James Watt Memorial Institute, Birmingham. "Some Aspects of Petrol Injection Equipment Development," by Messrs. K. Brook and W. E. W. Nicolls.

INSTITUTION OF SANITARY ENGINEERS.—Tuesday, March 23, 6 p.m., Caxton Hall, Victoria-street, S.W.1. Discussion on "Small Scale Sewage Disposal," opened by Mr. Donald Easdale.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, March 23, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Cycloidal Propulsion with Particular Reference to Voith-Schneider," by Captain E. C. Goldsworthy.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, March 23, 7 p.m., 198, West-street, Sheffield. "Some Techniques and Results in Metallurgical Research," by Dr. N. P. Allen.

HULL CHEMICAL AND ENGINEERING SOCIETY.—Tuesday, March 23, 7.30 p.m., Church Institute, Albion-street, Hull. "Modern Drying Practice," by Mr. H. D. MacMurray.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, March 25, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Torsional Constants of Structural Steel Sections," by Professor W. Fisher Cassie and Mr. W. B. Dobie.

INCORPORATED PLANT ENGINEERS.—*Glasgow Branch:* Tuesday, March 30, 7 p.m., 39, Elmbank-crescent, Glasgow. "Fuel Efficiency and the Plant Engineer," by Mr. J. B. M. Mason.

ROYAL UNITED SERVICE INSTITUTION.—Wednesday, March 31, 3 p.m., Whitehall, S.W.1. "Atomic Energy," by Professor H. S. W. Massey, F.R.S.

VALVE GEARS FOR 4-6-0 LOCOMOTIVES; LONDON MIDLAND REGION.

MR. H. G. IVATT, M.I.MECH.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see Page* 272.)

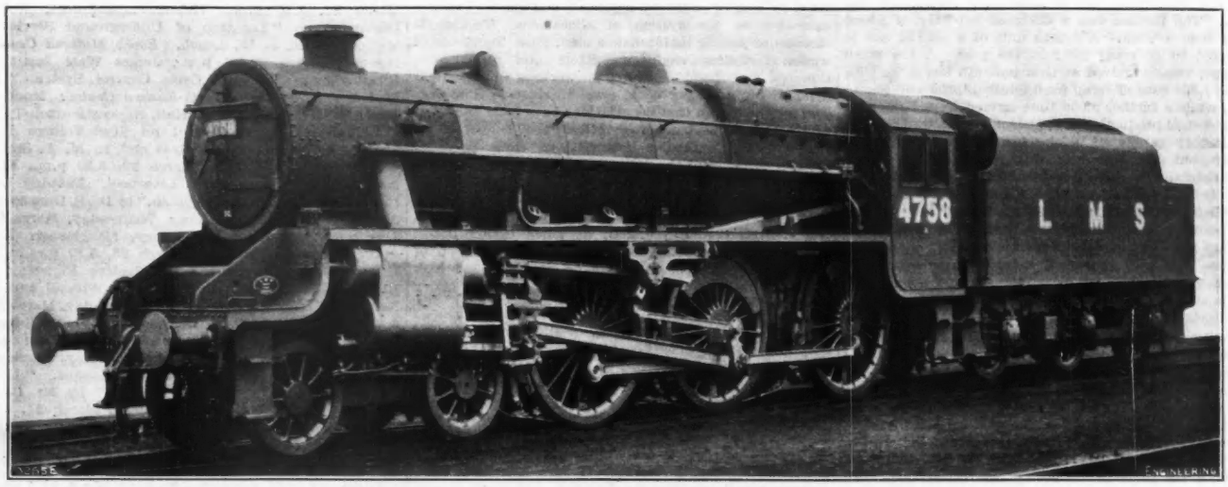


FIG. 5. STANDARD CLASS 5 LOCOMOTIVE WITH WALSCHAERTS VALVE GEAR.

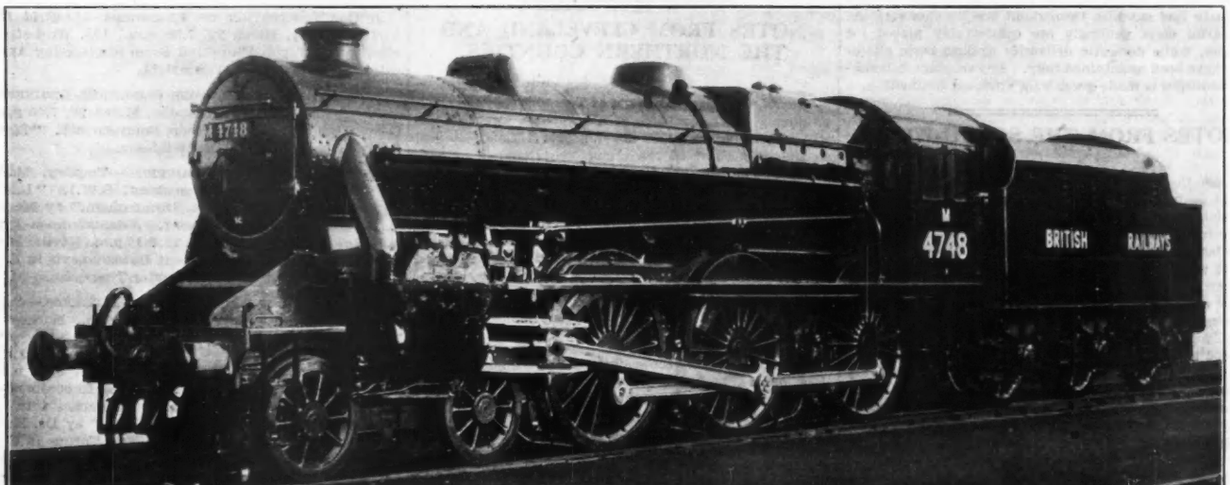


FIG. 6. CLASS 5 LOCOMOTIVE WITH CAPROTTI VALVE GEAR.

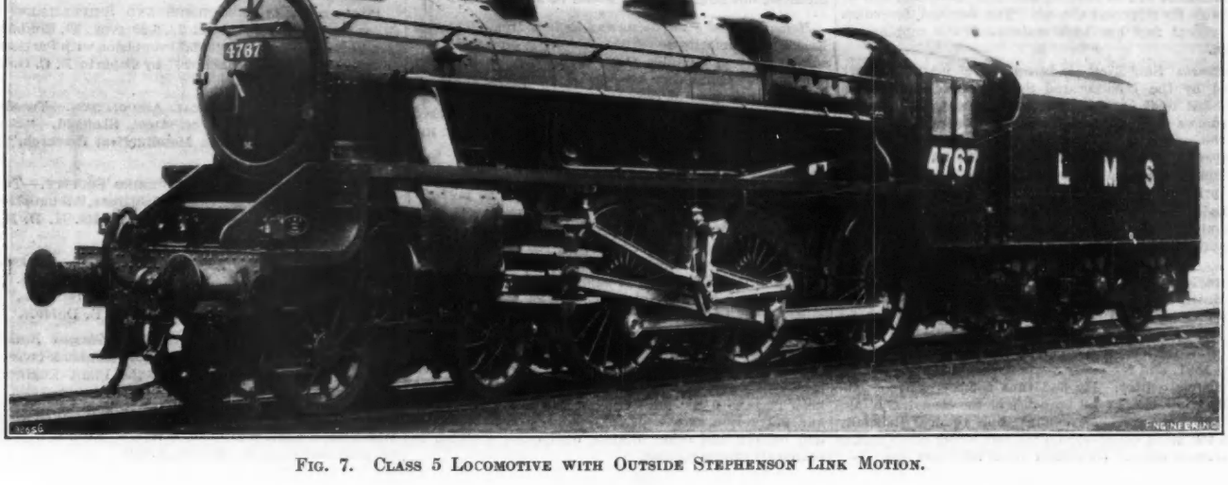


FIG. 7. CLASS 5 LOCOMOTIVE WITH OUTSIDE STEPHENSON LINK MOTION.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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INDEX TO VOL. 164.

The Index to Vol. 164 of ENGINEERING (July-December, 1947) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications

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ENGINEERING

FRIDAY, MARCH 19, 1948.

VOL. 165. No. 4286.

HYDRO-ELECTRIC POWER FROM THE NILE.

TO-DAY, March 19, His Majesty King Farouk of Egypt is to inaugurate a technical development which should be of far-reaching importance to his country and people, and hence, no doubt, to the economics of a large and important area bordering the eastern Mediterranean. By laying the foundation stone of the hydro-electric power station to be built at the Aswan Dam, His Majesty will bring appreciably nearer to realisation a project which has been under consideration for a number of years and on which work would have been well advanced by now, but for the interruption caused by the recent war. An outline of the scheme was given, in fact, as long ago as 1938, when Dr. Abdel Aziz Bey Ahmed, M.I.C.E., M.I.Mech.E., at the World Power Conference held in Vienna in that year, presented a paper on "Hydro-Electric Developments on the Nile as a Stepping-Stone to the Industrialisation of Egypt."* That paper was concerned largely with the Aswan Dam scheme, on which preliminary work has been in progress for some time under the direction of the Hydro-Electric Power Department of the Egyptian Ministry of Public Works; but this forms only a part of a much more extensive series of proposals now in process of development for the electrification of Upper Egypt, comprising plans for the generation of hydro-electric power from the barrages at Esna, Naga-Hamadi and Assiut, and the provision of a 275-kV transmission system to link them together.

When he read his paper at Vienna in 1938, Dr. Ahmed was Director-General of the Mechanical and Electrical Department of the Ministry of Public Works, but in June, 1945, the Egyptian Council of Ministers decided to appoint a special Hydro-electric Power Commission, with Dr. Ahmed as chairman and with wide terms of reference, the first of which was "To prepare specifications and conditions of tender for the Aswan Dam Hydro-electric Project and to make their recommendations on the tenders submitted, within the lapse of one year." In due course, the Commission submitted a detailed *Report on Economic Utilisation of Energy available from the Aswan Dam and Nile Barrages Hydro-electric Schemes*, signed by Dr. Ahmed, as chairman, and by Mr. W. J. E. Binnie, M.A., M.I.C.E., Mr. S. B. Donkin, M.I.C.E., Mustafa Bey Fathy, B.Sc. (Eng.), A.M.I.Mech.E., Dr. H. E. Gruner, M.I.C.E., Mr. Geoffrey F. Kennedy, M.A., M.I.Mech.E., M.I.E.E., and Ahmed Bey Khairy, B.Sc. (Eng.). In this report, the whole question of the utilisation as well as the generation of hydro-electric power was reviewed, the principal methods of utilisation, apart from meeting the normal electric-power requirements of Lower Egypt, being by the provision of a factory at Naga-Hamadi to produce artificial fertiliser, and of a steelworks at Aswan, with a designed annual output of 91,500 tons. It was stated, also, that the Commission proposed to deal in separate reports with other hydro-electric schemes, notably a possible scheme for utilising the peculiar features of the Qattâra Depression, which received so much prominence during the military operations in North Africa.

In the first stage of development, the power to be made available at the Aswan power station will vary from a maximum of 260 MW during the normal season of eight months to a minimum of 50 MW during the four months' flood season, on the basis of a reservoir level of 103 m.; though it is recommended that the possibility should be considered of raising the reservoir level during the flood season by at least another 2 m., to give some increase of power at that period. Even so, however, some 200 MW of the maximum output would be available only seasonally, for about eight months in the year, and any industries that might be established to make use of it must be of a kind that could be shut down at other times. Such industries, the report points out, could only afford to pay a low rate for power and careful consideration was given, therefore, to the selection of the industries best suited, in the light of this condition, to the general economy of the country. Eventually, as indicated above, it was decided to recommend the establishment of plant for the production of artificial fertiliser and iron or steel. It was estimated that, under the first stage of the scheme, it would be possible to achieve a combined output of 413,500 metric tons per annum of either product or any combination of both products. Under the second stage of the scheme—the erection of hydro-electric stations at the Esna, Naga-Hamadi and Assiut Barrages—the output could be increased to 526,500 tons.

The type of fertiliser recommended to be produced is nitro-chalk, a mixture of equal parts of ammonium nitrate and limestone which has been in common use in Egypt for many years but which hitherto has had to be imported. The consumption in 1939, it is stated, was 500,000 tons, but the demand is expected to reach 800,000 tons in the near future. The limestone required is available in abundant quantities at Esna and Naga-Hamadi, and it is the latter place which the Commission recommend as the site for the projected factory and its associated crushing plant for the limestone. The proposal to erect a steelworks also was influenced by the presence, in the neighbourhood of Aswan, of large deposits of high-grade iron ore, with an iron-oxide content which corresponds to a percentage of metallic iron varying from 38·3 to 61·6. Sulphur is almost entirely absent, and the percentage of phosphorus is low, so that the conditions are favourable for the extraction of the iron from the ore. It is suggested that steel furnaces, and rolling mills for the production of merchant bars and rolled sections might be located near the ironworks; but, if further examination of the economics of this proposal should indicate that the establishment of the steelworks at Aswan is not advisable, the output of the fertiliser factory could be increased by an amount corresponding to the steel tonnage projected. It was proposed, therefore, that the fertiliser plant should be designed at the outset for alternative productions of 322,000 or 413,500 tons per annum in the first stage of development, and 435,000 or 526,500 tons in the second stage, according to whether the steelworks is constructed or not.

The Aswan power station has been located on the west side of the Dam in order to make use of the low-level sluices to supply water to the turbines. This selection of site has the further advantages that the water can be discharged into the western channel, which is to be maintained always navigable; and that plant can be transported to the station by water. The Dam was built in 1902 for purposes of

* See ENGINEERING, vol. 146, page 453 (1938).

irrigation only and has been heightened twice since then, in 1912 and 1933, bringing the present storage capacity up to 5,000 million cubic metres with a reservoir level 32 m. above the water level of the river on the downstream side. Its total length is 2,141 m., and there are 180 sluices. Suggestions have been made to increase the height of the dam still more, but the Commission do not recommend it at this juncture, though provision is being made in the design of the station for such a development. There will be seven main turbines, each of 65,000 h.p., directly coupled to alternators having a rated continuous output of 47,000 kW at 0·95 power factor and generating current at about 11,000 volts. Each alternator will be directly connected to its own transformer bank, to raise the voltage to 275 kV.

The choice of Kaplan rather than Francis turbines is a result of the seasonal nature of the water supply. The Francis type would operate satisfactorily at the higher heads, but would not be satisfactory at the lower heads which obtain during the flood season; and therefore, if this type were used, the station would be shut down completely for some months during which the Kaplan type, with its adjustable blades, could still function. The range of gross head available is wide—between 33·5 m. and 8·0 m.—but this has been proved elsewhere to be well within the capacity of the Kaplan type. The cost of an installation of Kaplan turbines is naturally greater than that of a corresponding number of Francis turbines, but the greater availability, in the opinion of the Commission, more than justifies the extra outlay; moreover, the Kaplan type would operate more efficiently than the Francis type under the varying hydraulic conditions to be expected at other than the flood periods.

A matter of importance in designing the plant was that the stresses in the structure of the Dam should not be increased in such a way as to affect its safety, since, in the words of the Report, the Dam "has become, with the lapse of time, the mainstay of the agricultural wealth of Egypt." For this reason, the water is to be led to the turbines through a system of steel pipes inserted in the sluices—12 pipes, of a diameter of 1·8 m., to each turbine—which avoids the transmission of hydraulic stresses to the masonry of the Dam. There will be three of these penstocks in each sluice, arranged in a vertical tier, and they may be connected together in a variety of combinations. The penstocks will be joined by connecting them to surge tanks, an arrangement which is constructionally convenient as well as advantageous to the regulation of the turbines.

It will be seen from the foregoing summary of its main features that the project is one of considerable engineering magnitude, and of great economic significance to the future welfare of Egypt, since it will meet the whole of the estimated demand for electric power for municipal, industrial and irrigation purposes in the Aswan and Naga-Hamadi regions—which is expected to rise from the present level of 22 MW to about 43 MW maximum when the supply is available—and, in addition, provides the means to establish new industries of both direct and indirect benefit. The details of the financial considerations involved need not be elaborated here, though, obviously, they played a considerable part in determining the decision of the Egyptian Government to undertake a capital expenditure which is estimated to amount to some £E14,287,000 for the provision of the power station at Aswan and its associated electrical equipment and distribution network. At the present time, practically the whole of the power used in Egypt, whether mechanical or electrical, is produced from oil, either used as fuel in boilers or in internal-combustion engines, since the use of coal for power generation has become uneconomic; the price of coal, delivered c.i.f. Alexandria, is stated in the Report to be £E5·60 per ton, whereas the price of oil at Cairo is only £E5·00 per ton. A useful proportion—nearly two-thirds—of Egypt's oil requirements is met from domestic sources. It is eminently gratifying that, in the consideration and realisation of this great project, the Egyptian Government should have enlisted again the technical skill and resources of British engineers, with whom their own experts have collaborated so often and so successfully in the past.

ATMOSPHERIC POLLUTION.

IN the course of a paper read before the Institution of Mechanical Engineers in 1936, the late Dr. J. S. Owens said "it is estimated that in London the smoke from domestic fires is about 2½ times as great as that from industrial furnaces." No doubt the remark might have been extended to cover some provincial towns, although possibly not those containing numbers of large factories producing smoke and fumes. In the 12 years which have elapsed since the paper was read, it is possible that the proportional domestic contribution to the total smoke may have diminished to some extent owing to the greater employment of gas and electricity, but it is still likely to be a major factor. The objectional constituents of smoke are soot and tarry matter; grit and dust; and sulphur dioxide. The soot and tar are mainly produced by domestic fires and represent wastage of fuel owing to incomplete combustion. Many factory plants contribute their share, but the vigorous campaign for the efficient use of fuel carried on during the war has done much to improve works practice. Householders have been advised to contribute to smoke abatement by burning smokeless fuel and fitting improved grates, but as neither the fuel nor the grates are available in important quantity, such reduction in domestic smoke as has taken place has been due to a turn over to gas or electricity, and not to improvements in domestic fires.

Smoke abatement in its general aspects is the business of the Greater London Council on Smoke Abatement and corresponding provincial bodies. Most of these suspended their activities during the war, but many are again in operation. The attainment of the object in which they are interested is greatly assisted by the work of the Ministry of Health Inspectors, who are concerned with the application of the Alkali, etc., Works Regulation Act. As is clear from its name, this Act is not concerned with domestic smoke, but although in many large towns this may be the major factor in atmospheric pollution, it is not necessarily the most objectionable or most destructive. Chlorine, hydrogen sulphide and other offensive gases may escape in the carrying on of various industrial processes, and although their deleterious effects may be localised, they may be a serious menace to agriculture, and even property if they escape in undue volume. Other industrial exhalations may be unpleasant but inherently harmless, an example being furnished by the discharge from cement works, consisting largely of dried chalk and clay.

The annual reports of the Chief Alkali Works Inspectors, of which that for the year 1946 has just been published,* cover much more ground than their title would suggest. In addition to the sections dealing with works registered under the Alkali, etc., Works Act, much information is given about observations made at unregistered works, and the report as a whole may be said to cover all the main aspects of industrial atmospheric pollution. As this is the eighty-third report, it is clear that the practice of some type of control over alkali works is of long standing, which may explain why the relevant Act carries a somewhat misleading title; Alkali, etc., Works include those manufacturing sulphuric acid, nitric acid, chlorine, refining crude petroleum, recovering benzole, and carrying out other processes not to be described as alkaline.

It is natural that a large part of this report should be addressed mainly to industrial chemists, but some sections are of wider interest. An example is furnished by the information given about the control of fires in colliery spoilbanks. A colliery spoilbank is certainly not a registered works, but when it is on fire it may pollute the atmosphere for several miles around and become a justifiable source of complaint from residents in the neighbourhood. Matters of this kind are usually referred to the Alkali Works Inspectors by local authorities or Members of Parliament, and although the inspectors have no statutory authority they have given much assistance in devising remedial measures. During the war, they were given executive capacity in the matter by the Minister of Home Security, as a spoilbank which was burning sufficiently actively to show a glare or flames at night provided a guide for raiding bombers. It was fortunate that considerable work on the control of such fires had been done before the war, so that time had not to be spent on preliminary investigations.

The method of dealing with a burning spoilbank depends on its form and on the material from which it is made up. On flat spoilbanks, and also on conical banks composed mainly of coarse material, water spraying is effective. A fine spray is used, applied to cover the largest possible area in such a way that the bulk of the water percolates through the mass and does not form run-off channels. Fixed spraying pipes are not recommended as they direct the water continuously into one place and channels are cut in the surface of the bank. With conical banks made up of a mixture of coarse and fine material, a procedure known as "washing forward" has been adopted. In such banks, the large stones tend to roll to the base during tipping, the finer material remaining at the top. This results in a structure particularly favourable for burning, the coarse base acting as a grate for the entry of air. "Washing forward" consists in washing down fine material from the top to form a thick slurry round the base so as to seal the air inlet and choke the fire. The process obviously demands care and judgment; too copious a supply of water will carry the fines too far and merely increase the size of the bank, while an inadequate supply will cut channels on the surfaces. The success with which burning spoilbanks were treated during the war is shown by the fact that in England and Wales 142 examples were showing glare in 1939, while at the end of 1943 the number had been reduced to one. Of late, there has been some deterioration and at the end of 1945 the figure had risen to 20. There is now no objection to glare, but the accompanying atmospheric pollution is still undesirable.

It is stated in the report that a special investigation has been initiated into the question of the emission of fluorine and its compounds from various works. This matter was mentioned in the Scottish section of the eighty-second report, which dealt with the years 1939-1945. A case of window glass in houses in the neighbourhood of a superphosphate plant being dulled by hydrofluoric acid was referred to, but was not apparently considered of importance. The matter is now receiving more specific attention, as there is evidence that livestock have been injured as a result of feeding on herbage contaminated by fluorine. In the Marston Valley, in Bedfordshire, cattle have been seriously affected by fumes emitted from local brickworks. The Geological Survey states that the whole belt of clay from Peterborough to Oxford is relatively high in fluorides. As this is the most important brickmaking district in the country, the matter clearly demands the attention which it is now to be given. It is stated that the treatment of brickworks' chimney gases to free them from fluorine would be an engineering problem of great difficulty and might prove impracticable. It is clearly desirable that the matter should be investigated, but it is justifiable to point out that brickmaking has been carried on in this area for very many years, apparently without any undesirable agricultural reactions.

The section of the report of most direct engineering interest is, as usual, that concerned with grit and dust emission from power stations, and other steam plants, and industrial smoke generally. In many cases during the war not only were regulations regarding the production of dark coloured smoke waived, but it actually became desirable to produce smoke in order to decrease visibility and assist in camouflaging important industrial targets. That necessity has now passed, but the difficulties of approximating to smoke-free combustion have been increased by inadequate plant and the impossibility of obtaining new material, labour shortage and unsuitable and poor-quality fuel. These matters will slowly rectify themselves, and in the meantime it is well to remember, as the report says, that "the efficient use of fuel is of even greater importance than smoke abatement."

* *Eighty-Third Annual Report on Alkali, etc., Works by the Chief Inspectors.* H.M. Stationery Office. [Price 9d. net.]

NOTES.

THE INSTITUTE OF METALS.

As indicated in the programme published on page 202, *ante*, the fortieth annual general meeting of the Institute of Metals opened in London, at 2.30 p.m., on Tuesday, March 16, when four papers were presented for discussion. Contrary to the usual custom, the official business was conducted on the morning of the second day of the meeting, Wednesday, March 17. At the outset of this session, the chair was occupied by the retiring President, Colonel P. G. J. Gueterbock, C.B., D.S.O., M.A. After the presentation of the report of Council and the honorary treasurer's report, with which we intend to deal in a subsequent issue, it was announced that Sir Arthur Smout, J.P., had been elected President, Dr. S. F. Dorey, C.B.E., Mr. A. J. Murphy, and Mr. H. S. Tasker vice-presidents, Mr. W. A. C. Newman, O.B.E., honorary treasurer, and Mr. D. F. Campbell, Dr. Bruce Chalmers, Mr. T. M. Herbert, Mr. D. P. C. Neave and Mr. A. R. Powell, members of Council. Colonel Gueterbock then stated that the Institute of Metals Platinum Medal for 1948 had been awarded to Mr. R. C. Stanley, Chairman and President of the International Nickel Company of Canada, Limited, in recognition of his outstanding services to the non-ferrous metals industries. It was hoped that Mr. Stanley might be in Europe before the end of the year so that the medal could be presented to him at some future meeting of the Institute. If not, arrangements would be made for it to be presented to him in America. Colonel Gueterbock also announced that the 1948 May Lecture would be delivered by Dr. A. O. Rankine, F.R.S., on Thursday, May 13, and would be on the subject of geophysical prospecting; and that the annual autumn meeting of the Institute would be held in Cambridge from Tuesday, September 14, to Friday, September 17. The President's final announcement was that, only a few days previously, Messrs. W. H. A. Robertson and Company, Limited, had offered to the Council the sum of 100*l.* per annum, for a number of years, to provide awards for papers on the engineering aspects of metallurgy. Further particulars of these awards would be issued in due course. At this stage of the proceedings Colonel Gueterbock inducted the President-elect, Sir Arthur Smout, J.P., into the chair and, in doing so, drew attention to his distinguished services to the industry and to the Institute. A vote of thanks to the retiring President was proposed by the Hon. R. M. Preston, who, in the course of his remarks, referred to the awards, of 200*l.* per annum for a period of seven years, offered by the Councils of the Institute and the Institution of Mining and Metallurgy owing to the generosity of Colonel Gueterbock's firm, Messrs. Capper, Pass and Son, Limited, Bristol. Particulars of these awards will be found on page 255, *ante*. The vote of thanks was seconded by Major C. J. P. Ball, and, after a reply by Colonel Gueterbock, Sir Arthur Smout delivered his presidential address, which dealt with "Forty Years of the Institute of Metals." The address is reprinted, in abridged form, on page 285 of this issue.

THE ENGINEERS' GUILD.

The Engineers' Guild was founded, before the recent war, for the purpose, to state it very briefly and in broad terms, of providing for professional engineers those services which, by reason of the limiting clauses of their respective charters, the qualifying professional engineering institutions are unable to provide. To quote the Guild's own statement of its objects, it is concerned primarily with "the interests of engineers, and their relationship to the community": it does not duplicate any of the functions of the institutions, but is designed to supplement them and desires to co-operate with them in every possible way. It is not a trade union, but is seeking registration under the Companies' Acts, which is the form of incorporation adopted by the British Medical Association and other professional associations. During the war, the Guild was more or less in a state of suspended animation, but recently it has revived in no uncertain manner; and on March 10 a meeting convened at Caxton Hall, Westminster, with the object of re-stating the objects of the Guild and enlisting more extensively the support of the corporate members of the Institutions of Civil, Mechanical, and Electrical Engineers (to which the membership of the Guild is restricted) was very largely attended, an appreciable number of would-be participants being unable to gain admission to the hall. The chair was taken by Sir Peirson Frank, and the aims and objects of the Guild were expounded by Mr. O. V. S. Bulleid, past-president of the Institution of Mechanical Engineers; Dr. Percy Dunsheath, past-president of the Institution of Electrical Engineers; and Mr. A. S. Quatermaine, a member of the Council of the Institution of Civil Engineers. Mr. Bulleid said that there was a definite need for an association which could deal with questions of remuneration and working conditions, and encourage the acceptance by engineers of a greater degree of civic responsibility; which would keep before all Government departments and public authorities the importance of engineers; and which would inculcate a feeling of brotherhood throughout the profession. The Engineers' Guild, he submitted, could further all these objectives, but only if it represented an overwhelming majority of the profession. Dr. Dunsheath commented that other countries had attempted to organise their engineers on a professional basis, but had encountered many pitfalls; by coming in later, British engineers had the opportunity to avoid these difficulties and to prepare the way for a really strong professional body which would operate to the advantage of the public and the profession. Mr. Quartermaine emphasised that the Guild was completely non-political; its primary object was to attend to the non-technical interests of professional engineers—a duty which could not be undertaken by the existing Institutions. The Councils of these Institutions, however, were not antagonistic to the Guild; on the contrary, they recognised the value of a suitable association which could look after the interests of their members, in matters outside the scope of their respective charters. After a prolonged discussion, generally in support of the declared objects of the Guild, Sir Stanley Angwin put to the meeting, with the support of Dr. S. F. Dorey, a resolution "That this meeting strongly recommends all chartered civil, electrical and mechanical engineers to join, and actively to support, the Engineers' Guild." The resolution was carried *nem. con.*

THE INSTITUTION OF MECHANICAL ENGINEERS.

An extra general meeting, arranged in connection with the Applied Mechanics Group of the Institution, was held at the Institution of Mechanical Engineers, London, S.W.1, on Friday, March 12, the chair being taken by Professor H. W. Swift. Two papers were presented, these being by Professor J. L. M. Morrison, D.Sc., whose subject was "The Criterion of 'Yield' of Gun Steels," and Dr. W. M. Shepherd, on "Plastic Stress-Strain Relations." Professor Morrison, introducing his paper, explained that, while Professor J. J. Guest had demonstrated in 1900, and subsequent investigations had confirmed, that the yield of typical ductile materials was governed, to a first approximation, by the maximum shear stress, British and much foreign gun design, at the outbreak of the 1939-45 war, was based on the principal-stress or principal-strain theories. The Gun Design Committee of the Scientific Advisory Council therefore instituted the investigation which Professor Morrison's paper described, to determine the correct criterion of yield and plastic flow in the standard nickel-chrome-molybdenum steel normally used for guns, in the form of bar stock and gun-barrel forgings; and on seven alternative steels, as forgings, which were produced experimentally in the course of the war. It was found that, while the standard steel in the form of bar material gave a drop in stress at yield, the same steel in the form of forgings did not; neither did any of the alternative steels. In the first case, the criterion for the occurrence of initial yielding was found to be the existence of a critical maximum shear stress, plastic flow continuing in accordance with the von Mises-Hencky criterion; and, in all the other steels, plastic flow both occurred and continued as the von Mises-Hencky criterion indicated. It was noted, however, that the alternative steels displayed a wide variation of gradient in the early stages of plastic flow. Dr. Shepherd's paper, which followed, was an exposition of the derivation of stress-strain relations in cases such as a thick cylinder under combinations of internal pressure, longitudinal tension, and axial torsion, in which parts of the material were strained plastically while other parts remained elastic. The author developed a theory on the assumption that the amount of plastic flow was a function of von Mises' equivalent tensile stress, and an alternative theory, assuming it to be a function of the maximum shear stress; in each case, he showed how to deduce a shear stress-shear strain curve from a tensile stress-strain curve. He also demonstrated the application of the theory to a thin cylinder under combined tension and torsion. Most of the discussion centred on Professor Morrison's paper; possibly because, as the chairman observed, "in an analytical paper, the mathematics are either right or wrong; if right, they are unassailable and, if wrong, they are untenable." He described Professor Morrison's paper as "probably the most comprehensive investigation of the yield properties of a single material that has ever been published."

THE WORK OF THE LONDON POWER COMPANY.

In what is probably their final report, owing to the imminent acquisition of the undertaking by the British Electricity Authority, the directors of the London Power Company record that during the year ended December 31, 1947, the total output was 2,989,383,661 kWh, compared with 2,786,908,039 kWh during the previous twelve months. The maximum demand also increased from 686,400 kW to 720,280 kW. Of the total output, 1,812,546,280 kWh was distributed to constituent companies, this being almost the same amount as in 1946 owing to the fuel crisis. The remaining output to the Central Electricity Board was higher than before, a result which was made possible by improved plant availability at several of the stations. On the other hand, delays in manufacture have postponed the completion of the 66-MW extension of the Battersea "B" station until 1951, while shortage of labour and materials have retarded the establishment of the new distributing station at North Hyde, Middlesex, for the Metropolitan Electric Supply Company. The additional 22-kV inter-connector between Battersea generating station and the Horseferry-road distributing station should be completed during the latter part of the present year. Directions have been received from the Central Electricity Board for the reconstruction of Deptford East station by the installation of two 52·5-MW sets and four 250,000-lb. boilers. The reconstruction of the Willesden station is also under consideration. During the year, 972,022 tons of coal were carried in the company's own colliers, one of which—the Charles Parsons—was sunk in collision in the Thames. She has, however, been salvaged recently and been put into dry dock for repair.

SURVEY OF THE IRONFOUNDING INDUSTRY.

A considerable increase in the labour force in the ironfounding industry of this country and an appreciable increase in production, as compared with a year ago, are two leading features of a survey of the industry prepared by the Ministry of Supply and issued last week. On January 4, 1947, the process and maintenance employees engaged in the industry totalled 127,062. On April 5, 1947, the number had risen to 130,648, on July 5 to 131,366, and on October 4 to 134,292. The total on January 10, 1948, was 138,168, representing an increase of 11,106 for the year 1947. In spite of this, however, the Ministry point out that there are still large outstanding demands for both skilled and unskilled operatives. As an indication of output per man employed, two peak production periods have been taken into account by the compilers of the review, namely, the last quarter of 1946, when the output totalled 709,498 tons, with a labour force of 127,662, and the last quarter of 1947, when the output stood at 809,846 tons, with a labour force of 138,168; these figures represent, respectively, a production of 5·58 tons and 5·86 tons per operative for the two quarters. It is stressed that an important point to be taken into account is that, up till the end of 1946, the industry was working a 47-hour week, whereas since January 1, 1947, a 44-hour

week has been in operation. The total production of the industry for the first quarter of 1947 was 630,219 tons, for the second quarter it was 714,787 tons, for the third 691,533 tons, and for the fourth, as stated above, 809,846 tons. The sum of these four quarterly totals is 2,846,385 tons, and the figure for the last quarter represents an annual output of upwards of three million tons, whereas that for the last quarter of 1946 represented an annual output of 2,838,000 tons. The increased production has been directed towards meeting the growing demand for cast-iron pipes and fittings; agricultural, colliery and railway castings; and equipment for the electrical and chemical plant industries gas-producing apparatus, and iron and steel-works plant.

THE BRITISH CORPORATION REGISTER.

The 58th annual meeting of the British Corporation Register of Shipping and Aircraft was held in Glasgow on March 3, the chairman, Mr. Gilbert J. Innes, presiding. In reporting progress during the year under review, Mr. Innes drew attention to the fact that the Cardiff and Bristol Channel Incorporated Shipowners' Association and the North of England Shipowners' Association were now represented on the Management Committee; and added that the Technical Committee would shortly have direct representation from the Shipbuilding Conference, the Dry Dock Owners and Repairers Central Council, and the National Association of Marine Enginebuilders. A Canadian Committee had been established—a scheme which had been under consideration for many years—and held its inaugural meeting on June 11, 1947. After a lapse of nine years, it has been possible to resume the issue of an annual report, in the format so familiar before the war. In this it is stated that, though the tonnage of ships on the British Corporation Register was much reduced by war losses, the total is increasing again and, at the end of 1947, stood at 3,571,967 gross tons, representing 1,476 ships; and that the tonnage on order, subject to British Corporation survey, was about 463,000 tons at the same date. During 1947, 251 new ships, of an aggregate gross tonnage of 205,100, were added to the Register.

LETTERS TO THE EDITOR.

ENGINEERING UNITS OF FORCE.

TO THE EDITOR OF ENGINEERING.

SIR,—Having just noticed the recent correspondence in your columns on the units of mass and force, I venture to describe below a method of handling these units which has been proved by the experience of numerous teachers over many years to be quite satisfactory and to lead to a sound grasp of the quantities involved. It is believed to be due originally to Professor William Stroud. I do not claim that it will settle the "slug" controversy. Unfortunately—in the view of some—Professor Perry's legacy is a highly prized possession in some quarters, and it is not likely that it will ever be abandoned. It can be claimed, however, that with this method it does not matter which system is employed. The same formulæ apply and the same results can be obtained in any system with ease and confidence—an extremely desirable, although utilitarian, advantage!

The Second Law of Motion can be expressed as $F \propto ma$, for any one mass. This is somewhat glibly written as an equation $F = m\,a$ with the plea that the constant required to turn a proportionality into an equation can be made unity by a suitable choice of units, a step which is the cause of some of the confusion. However, accepting this provisionally, we have

$$F = m\,a. \quad . \quad . \quad . \quad (1)$$

where F, m and a stand respectively for the force, mass and acceleration, *i.e.*, the actual quantities themselves regardless of the units employed. This last is a very important point and needs to be thoroughly appreciated. (In teaching, the association of the symbol with the quantity, regardless of units used to measure it, is laid as a foundation before coming to the second law.) Now of the three related quantities F, m and a, any two can be fixed arbitrarily, but then the third must be derived from these two. This gives three possible systems, each of which has its devotees, although in reality they are closely related.

A special case of the above equation is

$$W = m\,g. \quad . \quad . \quad . \quad (2)$$

Now let the weight (or force) of one pound be written 1 Lb. and the mass of one pound be written 1 lb. The acceleration produced when the weight (or force) of 1 Lb. acts on a mass of 1 lb. is 32·2 ft./sec² (or whatever the value of g happens to be).

Hence equation (2) becomes

$$1\text{ Lb.} = 1\text{ lb.} \times 32{\cdot}2\text{ ft./sec.}^2 \quad . \quad . \quad (3)$$

This equation expresses one of the "gravitational" systems, here designated the "engineer's" system of units, in which the pound force (1 Lb.) and the pound mass (1 lb.) are respectively the arbitrary units of force and mass. The derived unit, for acceleration, might be called 1 "gee," but it is simpler to express it as 32·2 ft./sec.²

If it is preferred, following Perry, to fix arbitrarily the units of force and acceleration we use for them, respectively, 1 pound force (1 Lb.) and 1 ft./sec². In effect we change the place of the number 32·2 and write the equation 1 Lb. = 32·2 lb. × 1 ft./sec². Now a mass of 32·2 lb. has been given the unhappy name of "slug," so the equation becomes 1 Lb. = 1 slug × 1 ft./sec.² The third possibility is to fix arbitrarily the units of mass and acceleration as 1 pound mass (1 lb.) and 1 ft./sec.² which enables us to write equation (1) as 1 poundal = 1 lb. × 1 ft./sec.²

This is usually claimed to be an absolute system in that it is independent of gravity, but it is so only as long as it keeps in a world apart. As soon as it is desired to express the poundal in terms of the pound weight it is necessary to bring back the 32·2 again. In fact the last equation can be derived from equation (3) by another change in the position of the number 32·2 thus:—

$$\frac{1\text{ Lb.}}{32{\cdot}2} = 1\text{ lb.} \times 1\text{ ft./sec.}^2$$

Collecting the three systems for comparison we have:

1. $1\text{ Lb.} = 1\text{ lb.} \times 32{\cdot}2\text{ ft./sec.}^2$
2. $1\text{ Lb.} = 32{\cdot}2\text{ lb.} \times 1\text{ ft./sec.}^2 = 1\text{ slug} \times 1\text{ ft./sec.}^2$
3. $\frac{1\text{ Lb.}}{32{\cdot}2} = 1\text{ poundal} = 1\text{ lb.} \times 1\text{ ft./sec.}^2$

Now may I return to the constant which, by this time, has usually been forgotten. The equation expressing the second law must be written, in its complete form, as $F = k\,m\,a$ where k is a constant. In the same manner we have $W = k\,m\,g$ and from this, using the units already chosen, we can get the value of k thus:—

$$k = \frac{W}{m\,g} = \frac{1\text{ Lb.} \times \text{sec.}^2}{1\text{ lb.} \times 32{\cdot}2\text{ ft.}} \text{ for the engineer's system,}$$

$$= \frac{1\text{ Lb.} \times \text{sec.}^2}{32{\cdot}2\text{ lb.} \times 1\text{ ft.}} \text{ for the Perry system,}$$

$$= \frac{\frac{1}{32{\cdot}2}\text{ Lb.} \times \text{sec.}^2}{1\text{ lb.} \times 1\text{ ft.}} \text{ for the absolute system,}$$

and it will be noted that it has the same value in all cases. Now for numerical work write equation (1) in the form $F = k\,m\,a$ and by substituting for k we have

$$F = m\,a\left[\frac{\text{Lb. sec.}^2}{32{\cdot}2\text{ lb. ft.}}\right].$$

The expression in square brackets has come to be known as a "unity bracket" (since its value is unity) and its use is of inestimable value in all calculations related to mass and force. The student soon learns to use it and has in consequence no need to "divide by 32·2" because his answer looks too great! A simple example is given below.

To find the centripetal force necessary to constrain a mass of 5 lb. to move in a circle of 4 ft. diameter at a speed of 300 rev. per minute:—

$$F = m\,\omega^2 r = 5\text{ lb.} \times \left(\frac{300 \times 2\pi}{60\text{ sec.}}\right)^2 \times 2\text{ ft.} \left[\frac{\text{Lb. sec.}^2}{32{\cdot}2\text{ lb. ft.}}\right]$$

$$= \frac{1{,}000\,\pi^2}{32{\cdot}2}\text{ Lb.} = 307\text{ Lb.}$$

Note, that all other units cancel leaving the result in pounds force. If the answer is desired in poundals the unity bracket is written

$$\left[\frac{\text{pdl sec.}^2}{\text{lb. ft.}}\right],$$

or if the mass is given in slugs the unit bracket is

$$\left[\frac{\text{Lb. sec.}^2}{\text{slug ft.}}\right].$$

This method holds equally well for all formulæ in kinetics.

It will be noticed that an important incidental in the above is the difference in the symbols used for mass and weight. Other methods of making the distinction have been used by others, but the one used here has the advantage of brevity and adaptability to any size of unit, e.g., Lb., lb.; Ton, ton; Gm., gm., etc. The teacher will deal ruthlessly with any tendency on the part of the student to speak of "big pounds" and "little pounds" since the difference is not one of size but of essential nature. When this method is used the units of mass and force are robbed of all their terrors. Moreover any of the three systems can be employed equally well, or a change made from one to the other in the course of a calculation.

While the above does not attempt to settle the arguments between the protagonists of the slug, the poundal or plain g—which will probably always be a matter for personal predilection—it is hoped that it will demonstrate that all systems can be handled with equal ease. This may possibly be of some help to Mr. Lennie and others whose business it is to teach the subject.

Yours faithfully,

CHAS. H. HELMER.

Royal Naval College,
Greenwich, S.E.10.
March 5, 1948.

COUNCIL ELECTIONS IN PROFESSIONAL INSTITUTIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read the letter of Mr. Michael Birkin, on page 256 of your issue of March 12, 1948, with interest; the system which he recommends appears to work well, though it is cumbersome.

For 50 or more years there has been an undercurrent of discontent about several things in connection with professional institutions, and especially about the election of the members of Council of the Institution of Civil Engineers. This discontent is most unfortunate, and cannot do the profession or the Institution any good. If the members were really free to elect whomsoever they wished, I think that their complaints would soon be attended to. As long ago as January 31, 1908, you published a letter of mine which proved it to be impossible for any member, not on the balloting list prepared by the Council, to be elected to the Council; and the reason for this was shown to be due to what I called the "mob-voting system." By this I mean the regulation which compels members to vote for a fixed number of candidates, instead of only for those whom they know and wish to elect. In 1910, I took part in the uniting of the Society of Engineers with the Civil and Mechanical Engineering Society to form the present Society of Engineers, Incorporated, and persuaded the Council to let the members be really free when voting for the election of their Council. This has been done for nearly 40 years by two simple regulations: (1) if a member is sufficiently supported, his name must appear on the ballot list; and (2) a member may vote for any number of candidates not exceeding the number to be elected. At that time it was objected that voting for as few as a member wished would result in large changes in the personnel of the Council and thus upset matters in hand. This has not occurred in the case of the Society of Engineers for the past 38 years, and during that time there has not been any deplorable smouldering discontent such as has recently occurred again elsewhere.

Yours very truly,

A. S. E. ACKERMANN.

9, Rotherwick-road,
Hampstead Garden Suburb,
London, N.W.11.
March 16, 1948.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE 1948 Spring Meeting of the Institution of Naval Architects opened on the morning of Wednesday, March 17, the chair being taken by the retiring President, Admiral of the Fleet Lord Chatfield, G.C.B., O.M. The annual report of the Council, for 1947, was summarised by the secretary, Captain (S) A. D. Duckworth, R.N. (retd.), who observed that the membership of the Institution had increased from 2,973 at the end of 1946 to 3,108, twelve months later. He announced also that the Institution Premium had been awarded jointly to Mr. T. Thorpe, R.C.N.C., and Mr. K. C. Farrell, B.Sc., R.C.N.C., for their paper on "Permanent Moorings"; the Wakeham Prize had been awarded jointly to Mr. E. C. B. Corlett, B.A., and Mr. K. Foulger, B.Sc., for their paper on "Stability Losses on Flooding"; and that the Newell Prize of 25*l*., presented by Mr. W. S. Newell, President of the American Society of Naval Architects and Marine Engineers, had been divided between Mr. R. M. Hamill (15*l*.) and Mr. J. W. Eckhard, B.Sc. (10*l*.). The Premium, and the Wakeham Prize, were presented subsequently to Mr. Thorpe, Mr. Farrell and Mr. Corlett. Among other items in the annual report, it was mentioned that the revised by-laws of the Institution, accepted by the corporate members at a meeting held in October, 1947, had been approved by the Privy Council and were in operation; and that the Southern Junior Branch, in which the Institution co-operated with the Institute of Marine Engineers, was highly successful.

The retiring President, Admiral of the Fleet Lord Chatfield, then invited the meeting to approve the appointment of his successor, Admiral of the Fleet Viscount Cunningham of Hyndhope, O.M., saying that it was a great pleasure to be able to hand over this office to so distinguished a sailor—the outstanding naval figure of the second World War. During Lord Cunningham's anxious years in the Mediterranean the brilliant naval air attack on Taranto had been successfully carried out; and he had led his fleet into night action with the Italian navy off Matapan—a unique action, reminiscent of Nelson's night action at the battle of the Nile. He had started at a great disadvantage, but in the end he was able to signal to the Admiralty that the Italian fleet was safely anchored under the guns of Malta. He had the great advantage that his name was known throughout the world and that, therefore, distinguished naval architects and naval officers from foreign countries would know him and would be glad to see him in the presidential chair of the Institution. Lord Cunningham's appointment as President was approved by the meeting with prolonged applause.

Sir Stanley Goodall then proposed the hearty thanks of the Institution to Lord Chatfield for his work as President during the preceding seven years. The proposition was seconded by Sir Harold Yarrow and was carried with acclamation.

Lord Chatfield, having briefly acknowledged the thanks of the members, then vacated the chair in favour of Lord Cunningham, who proceeded to announce the result of the elections of Council members, which were as follows: as Vice-President, Dr. J. M. McNeill; as Members of Council, Mr. John Baird, B.Sc., Mr. George Barrie, Vice-Admiral (E.) D. C. Ford, C.B., C.B.E., Mr. R. W. L. Gawn, O.B.E., Sir Summers Hunter, Mr. Henry Main, C.B.E., Mr. D. E. J. Offord, Mr. J. M. Ormston, M.B.E., and Mr. H. B. Robin Rowell; as Associate Members of Council, Mr. Alexander Belch, C.B.E., Sir Charles G. Darwin, K.C.B., F.R.S., and Captain F. G. Spriddell, C.B.E.

Admiral of the Fleet Lord Cunningham then delivered his presidential address, of which the following is a somewhat abridged report.

PRESIDENT'S ADDRESS.

In the course of a long career afloat, said Lord Cunningham, I have sometimes been known to hold and express some outspoken opinions on naval architects and their achievements; and it is perhaps inevitable that, when one takes the successful solution of so many constructional problems for granted, one is inclined to note more particularly those problems which have, perhaps, not yet been so happily solved, and to stress the weakness of this or that feature in design without realising all the difficulties involved in effecting a remedy. As a life-long user of ships, I find this a very easy habit of mind to acquire, and it is with the greatest interest, therefore, that I now hope to learn more of the reverse side of the picture. In common with every other great maritime nation, we are approaching some very difficult problems, problems that are of infinitely greater moment to the future of this country than ever before. We shall need to keep our heads and combine the wisdom of the past with a progressive outlook.

So far as warship building during the past year is concerned, little information on current naval construction has been issued. The construction of warships has been further retarded by the priority given to building ships of the mercantile marine, by the large arrears of repairs and reconditioning work, and by the shortage of materials, including steel and timber. As was seen from the Naval Estimates, the production of aircraft carriers is continuing slowly, though some vessels have been stopped and others disposed of to friendly Powers. The lengthening times of construction enable modifications to be introduced so as to keep pace with developments in aircraft; nevertheless, such improvements made while building bring difficulties in their train, as every shipbuilder appreciates. Cruisers, destroyers and other naval vessels are also continuing at reduced pace, an interesting feature being the conversion of a large number of warships to peaceful purposes. Frigates are being adapted to surveying uses; corvettes have become weather observation ships. I would mention in particular the ex-German supply vessel now converted to the fleet replenishment ship Bulawayo. This vessel has been equipped so that, while proceeding at speed, fuel, water and stores of all descriptions can be transferred to an accompanying warship proceeding alongside.

Although the naval shipbuilding programme is small, it can be seen that the Admiralty fully appreciate the important part that research and development will play in the future designs of ships and weapons, since a large programme of research has been authorised and is being pursued with vigour. An instance is the formation of the Admiralty Ship Target Trials Committee, who are undertaking a series of experiments, using surplus warships as targets, to obtain reliable data bearing on the effects of weapons of all kinds on a ship's structure and equipment. A very important item of research is that devoted to the various problems connected with the welding of a ship's structure; for instance, the Admiralty Ship Welding Committee has concluded a valuable programme of structural investigations on the two ships, Ocean Vulcan (welded) and Clan Alpine (riveted).

Naval architecture must be inseparably bound up with marine engineering. Most of the machinery in warships is steam-driven, and, although considerable advances have been made, a step forward into the field of higher steam pressures and temperatures is inevitable in the future. It was the intention when ordering the Daring class, to spread the orders over the whole marine-engineering industry and so to enable all firms to gain experience in this new field. Unfortunately, owing to the cancellation of the majority of ships in this class, only a few firms will get this experience. It is considered that all the future larger ships of the fleet will be fitted with higher pressure and temperature steam plants, and a theoretical investigation into the whole problem is being carried out to decide on the best practical steam conditions for the future. In the Daring class, these different turbine designs and four different boiler designs are being tried out.

As regards internal-combustion engines, the war brought the advantages and reliability of this class of machinery much to the fore. A high-power lightweight Diesel is being developed for use in coastal craft. Trials with gas-turbine machinery in M.G.B. 2009 are proceeding; an important point in future design here will be to obtain efficiency over the whole range of power. As regards future policy, the aim should be to fit steam machinery in the high-power field, internal-combustion engines in the low-power field, and, perhaps, gas turbines may fill up the middle field or even encroach on to others. Concurrent with the installation of gas turbines may be discerned a trend towards the application of variable-pitch reversible propellers, brought about by the need for new methods of reversing, and also due to the application of higher steam pressures and temperatures in geared-turbine installations.

But few of the fruits of present work on future design can be gathered unless the shipbuilders of the country are allowed to procure the material required for the purpose. What the industry needs, and what the whole country needs, is steel, and all the other materials required for shipbuilding. The capacity of the plant and berths of the shipbuilding industry, under the condition of full supply of labour and material, is capable of meeting a demand of about three million gross tons, if expressed entirely in merchant ships. At the present time, the annual rate of output is restricted to less than one million tons because of the inadequate supply of materials. At the corresponding period following the 1914-18 war, the rate of output was about two million gross tons. In the White Paper (*Economic Survey for* 1947) of February, 1947, the Government gave a target amount of 1·25 million gross tons for 1947—a figure far below that for which the industry had planned; but steel materials were neither allocated nor delivered to produce more than about one million tons. The figures given in the White Paper (*Capital Investment in* 1948) of December, 1947, correspond to an addition of 20 per cent. on that of 1947, for which the industry had hoped the necessary additional materials would be made available; but the present position is that it can expect only slightly more steel than that which was allocated in 1947. It is obvious that the present restricted condition in regard to material supplies, with all the accompanying frustrations, does not permit of operation at any reasonable economic level. British shipbuilders have orders on their books amounting to nearly 4¼ million tons. The load of repair and re-conversion work continues to exceed three million tons.

Shipbuilders may feel justly proud of what they have been able to achieve in the past year, and the country equally confident of what the shipping industry could do for it if allowed to. Some 2,170,000 gross tons were under construction at the end of 1947 and 1,200,000 tons were launched during the year. The construction in Great Britain and Northern Ireland represented over 54 per cent. of the total for the whole world; 31 per cent. of this construction was being built for foreign account. These figures relate to new construction, but that is by no means the whole story. Reconversions of ships for their peace-time service, and the carrying out of repairs and surveys on merchant ships, have placed an additional heavy load on the industry during the year. Doubtless this load of reconversion work will fall away towards the end of the present year.

The work of the British Shipbuilding Research Association, British Welding Research Association, the Admiralty Ship Welding Committee and other kindred bodies, is having a definite and beneficial influence on the science and art of shipbuilding. This is encouraging, but I would like to express agreement with, and to emphasise, a point of view expressed by Lord Chatfield in the House of Lords in October: he said "We would all agree that there is nothing more important for the three Services than Research. But we must be careful how the priority given to Research is used. It was used during the Peace Years as a means of preventing anything being done for the Services. We are told 'Go on experimenting; do not build anything because the scientists may change things next year.' But the scientists are always changing things, and you will never have any Services at all if you start on that line." These words have a much wider application than to the Services only. It is fatally easy to acquire a research habit of mind. What the country wants is the improved ship which is the result of that research, and there comes a time when some practical solution of a problem—it may not be the final solution—is essential.

(To be continued.)

AUTOMATIC CENTRELESS GRINDING MACHINE.

DURING recent years, the range of components which can be produced on centreless-grinding machines has been increased considerably. One of the more recent developments is the use of centreless-grinding machines for form grinding, a process which necessarily entails the adoption of the plunged-cut method wherein the control wheel is withdrawn from the grinding position after the feeding operation. Originally the control wheel was manipulated by hand but in certain instances this operation can now be carried out mechanically in synchronisation with an automatic feed device.

Several machines of this type have been manufactured by Messrs. The Churchill Machine Tool Company, Limited, Broadheath, Manchester, and, in addition to other applications, were employed during the recent war on the production of automobile pistons and 20-mm. shells. A centreless-grinding machine of the fully-automatic type recently manufactured by this firm is illustrated on this page, the machine having been designed for the form grinding of balance staffs for clock mechanisms. The balance staffs are finish ground on their major diameters and at their tapered ends in one operation after having been form turned 0·005 in. oversize and hardened, the complete grinding operation taking three seconds.

Basically it is a standard centreless-grinding machine with the addition of a regulating unit, which determines the movement of the control wheel and the feeding of the components, and a profiling attachment in the grinding-wheel dresser. The regulating unit is fitted to the right-hand end of the machine, as viewed in the illustration, and it consists of a worm and worm wheel, the worm being driven by a constant-speed electric motor located under the regulating unit. The axis of the worm wheel is along the length of the machine and it rotates about a shaft free to move in an axial direction only. A scroll cam is integral with the shaft and the cam engages with a roller fitted to the worm wheel so that rotation of the worm wheel displaces the shaft axially. The carriage for the grinding-control wheel is free to move along its slide and the end of the carriage remote from the control wheel is held in contact with one end of the shaft by the action of a weight suspended on the end of a chain, the chain being attached to the carriage. It will be appreciated that as the worm wheel rotates the action of the roller on the scroll cam will cause the shaft and, therefore, the control-wheel carriage, to be displaced along the length of the machine, the actual movement of the carriage depending, of course, on the contour of the scroll cam. In this particular application, the cam is shaped so that the carriage is advanced rapidly towards the work piece, slowed down to the grinding feed and, after grinding is completed, returned to the starting position.

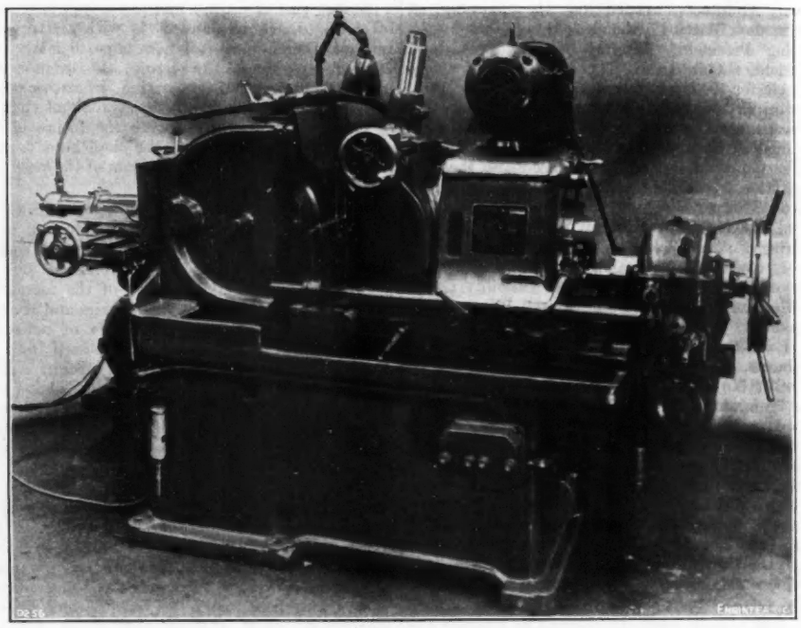
Insertion of the balance staffs into the grinding station and their subsequent ejection after grinding is fully automatic. The parts are stored in a vertical hopper adjacent the side faces of the grinding and control wheels and they fall from the hopper on to a platform which brings them into correct alignment for entry into the throat formed between the grinding and control wheels. The balance staffs are fed into the throat by a plunger which is reciprocated by a cam fitted to the worm wheel of the regulating unit. The cam operates a tappet which, in turn, makes contact with a lever secured to one end of a horizontal shaft located along the front of the machine. The feed plunger is operated by a further lever splined to the opposite end of the horizontal shaft, the top of the lever entering a slot formed in the end of the plunger remote from the grinding wheel; the horizontal shaft and the lever for actuating the plunger can be seen in the illustration. Operating the plunger from the regulating unit ensures that the cycle of feeding the parts synchronises with the movement of the control wheel.

DISPOSAL OF GOVERNMENT STORES OVERSEAS.—The gross receipts realised by the Ministry of Supply from the disposal overseas of surplus stores were 95,000,000*l.* in 1946 and 63,000,000*l.* in 1947.

INSTITUTION OF PRODUCTION ENGINEERS.—We have received a preliminary notice regarding the first annual convention of the Institution of Production Engineers. This will be held at Bournemouth from Thursday, September 23, to Saturday, September 25. There will be a civic reception on the evening of September 23 and addresses by prominent industrial men will be delivered on the mornings of September 24 and 25. In addition, discussion groups will be organised to deal with subjects of interest to production engineers and a special evening function is being arranged. Further particulars and forms of application for reservations may be obtained on application to the secretary of the Institution, 10, Seymour-street, London, W.1.

AUTOMATIC CENTRELESS GRINDING MACHINE.

MESSRS. CHURCHILL MACHINE TOOL COMPANY, LIMITED, MANCHESTER.



STANDARDISATION OF SWITCHGEAR.*

By D. E. LAMBERT and J. CHRISTIE.

THE standardisation of switchgear may be broadly interpreted as unifying requirements and performance, as far as practical conditions will permit, and reducing the varieties of types, constructions and auxiliary equipment to a reasonable minimum. The extent of standardisation possible is controlled by the variety of applications, functions, service conditions and technical methods. This, coupled with variety of detail in products intended for the same purpose, has resulted in a large number of types and constructions. In connection with any attempt to achieve a fuller measure of standardisation both users and manufacturers have responsibilities. At the present time, there are in Great Britain about eight manufacturers of switchgear up to the maximum size required, about 23 manufacturers of smaller sizes up to, say, 250 MVA, and a very much larger number who manufacture distribution switchgear for 660 volts. In addition, many manufacturers make their own auxiliary equipment. Rationalisation would assist in producing economical ranges of switchgear, owing to the savings brought about by quantity production, more efficient use of manpower, less duplication of elaborate research, development and testing facilities; and the pooling of patents, which would avoid competitive constructions designed differently from (but not necessarily better than) those that had been patented.

The application of standardisation in conjunction with a measure of rationalisation would tend to increase the quantities of individual products to such an extent that quantity-production methods could be advantageously adopted. Quantity production is not in itself, however, sufficient to furnish the most economical product, since other factors, such as research, cost of selling and distribution, and overhead charges, need co-ordination if the total cost is to be spread over a large output and a lower cost per article secured. Greater standardisation of switchgear as a whole could be promoted by reducing the number of ratings of standard circuit breakers; by users' acceptance of standard switchgear with fewer additional requirements than are often specified at present; by the establishment of provisional standards while the standard specifications are being revised; and by standardising auxiliary equipment. The benefits that would accrue from such standardisation are the larger quantities of a reduced number of standard circuit breakers and auxiliary equipment; "freezing" of designs for longer periods, which, in turn, would allow greater quantity production and cheaper products; more readily available products; fewer spares; and more man-hours available for progressive management and research.

The standardisation of supply-system requirements is closely associated with the layout and arrangement of networks and of the controlling switchgear. British Standard No. 116-1937 contains schedules showing 131 varieties of standard circuit breakers. Direct comparison of the various national rated voltages is liable to be misleading as this is often not the maximum operating voltage. Since the basis on which the insulation of a circuit breaker should be designed is the maximum voltage at which it can work continuously, it would seem logical to adopt this as the rated voltage of the equipment. The MVA values at various points on a network due to faults may differ considerably; and this may involve sectionalising or the use of reactors or transformers in order that the switchgear rating may not be exceeded. From the point of view of standardisation, it would be of considerable assistance if there were a reduction in the number of ratings and if international agreement could be reached on breaking capacities. The same is true of normal current ratings. The severity associated with short-circuit operation on a system is usually less than that inherent at short-circuit testing stations. It is, therefore, necessary that more information should be obtained on the conditions of severity that exist on networks, so that exceptional cases can be dealt with either by the supply authority or by taking care that the switchgear is suitable for them.

Standardisation of performance requirements for rating is a first essential to ensure a comparable degree of excellence as regards reliability or proper functioning of switchgear. Much work has been put into the preparation of British Standard specifications on this subject, while the standardisation of the interpretation of circuit-breaker performance has been taken a step farther as the result of the work done at British short-circuit testing stations. The draft of the revised British Standard No. 116-1937, in fact, contains much information based on recent experience both on site and at testing stations. In addition, however, the investigation of the severity conditions associated with short-circuit performance in relation to service is necessary both by the testing stations and research associations. It is also desirable that insulation levels, including impulse-voltage tests and flashover tests, should be co-ordinated, while in future it may be necessary to specify tests to deal with the behaviour of circuit breakers when switching capacitance currents.

The first considerations in the selection of switchgear are the purpose, the duty and the operating conditions for which it is intended. The required duty and the site conditions largely determine whether indoor or outdoor metal-clad, metal-enclosed or open-type switchgear is the most suitable. Generally speaking, however, outdoor open-type switchgear of a number of types is in common use from 110 kV to 264 kV. From 110 kV

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to 132 kV small-oil-volume and air-blast circuit breakers are frequently employed indoors. At 66 kV, indoor metal-clad or open-type switchgear has been adopted for the more important generating and distributing stations and open-type outdoor switchgear for the less important. At 33 kV and lower voltages, it is customary to install metal-clad or metal-enclosed switchgear in buildings. For rural distribution the type of switchgear for the higher voltages is determined mainly by the incoming and outgoing connections. If these are bare overhead lines, outdoor switchgear is adopted. With cable connections, and generally at lower voltages, it is usual to install metal-clad switchgear indoors or in kiosks.

The three principal types of 'bus-bar arrangement are the single, double and ring, while the mesh connection is used occasionally. The type chosen naturally affects the construction of the switchgear. Considerable simplification in the design and construction of the switchgear could be achieved by the adoption of the single 'bus-bar arrangement where possible. Although this arrangement is the simplest it is, however, also the least flexible and it has its main application in distribution stations. The 'bus-bar is usually split into sections coupled by switches or circuit breakers, thus increasing the flexibility, particularly if duplicate feeds and feeders are connected to different sections. Extensions, maintenance and testing of the 'bus-bar insulation are possible without shutting down more than one section of the 'bus-bar at a time. Double 'bus-bars provide greater flexibility than single 'bus-bars and are in general the most suitable for generating stations and major transmission and distribution stations where the number of feeders is large compared with the number of machines. With this arrangement, the 'bus-bar insulation can be tested and the switchboard extended without interrupting the supply. Selected circuits can be connected together on the stand-by 'bus-bars and operated separately from the remainder. The network also can easily be sectionalised for load distribution. The construction and layout of the switchgear, however, tend to become uneconomical when it is desired to separate the 'bus-bars, so that if one set is damaged the other is unaffected. Further, with double 'bus-bar metal-clad switchgear the method of selection varies considerably; and it is not easy to provide a completely satisfactory and economical arrangement for the larger sizes.

For these reasons, ring 'bus-bars have been adopted at many main generating stations and transmission and distribution stations in Great Britain where the loading per ring is such that the number of circuits is limited. The features of the ring 'bus-bar system are that one section of the 'bus-bar can be isolated from the remainder without affecting the supply to other circuits. It is economical in the number of circuit breakers and isolators required, compared with equivalent double 'bus-bars. All the switchgear is identical, since no special section or coupler circuit breakers are required. The maximum circuit-breaker current rating required is normally less than for double 'bus-bar circuits with which heavy-current 'bus-bar coupler circuit breakers are required. The 'bus-bar protection is also less complicated than with double 'bus-bars. The disadvantages of the arrangement are that the number of circuits per ring is limited and great flexibility of operation is not possible, unless the number of outgoing circuits is less than twice the number of incoming circuits.

With mesh-connected switchgear there are, in effect, no 'bus-bars and each circuit is controlled by two circuit breakers one on each side of the tie point of the circuit. This eliminates the need for special 'bus-bar protection, since overlap-protection, is provided on all circuits, the current transformers for any circuit being connected on the sides of the circuit breakers remote from the circuit to be protected. This means, however, that every circuit requires two sets of current transformers, which must operate in parallel; and for this reason the protection and the metering circuits become complicated. Further, each current transformer must be able to carry the maximum current that may flow round the mesh no matter what the rating of the associated circuit may be. The design of the current transformers also becomes difficult if there is wide disparity between the normal current ratings of the mesh and of the circuit. All the circuit breakers must be of the same size, namely the largest, since they, too, must be able to pass the maximum current that may flow round the mesh. The major disadvantage of mesh connection is that a circuit fault necessitates the tripping of two circuit breakers and an interruption of the mesh. If it is broken elsewhere for any reason it becomes split up into a number of individual parts and in an extreme case there may be a complete shut down. It is possible, however, to maintain a circuit breaker without interrupting any circuit. Mesh connection involves the same limitation on the number of circuits and their arrangement as a ring 'bus-bar. In addition, when testing the protective gear, it may be necessary to have two or three circuits out of commission at once.

As the layout of indoor and outdoor open-type high-voltage switchgear for main transmission and distribution stations involves an assembly of self-contained and separate items, there is complete freedom of choice of 'bus bar. The double 'bus-bar arrangement is usually preferred to facilitate cleaning and insulator maintenance. Double 'bus-bars are also common for metal-clad or metal-enclosed switchgear for secondary distribution stations and industrial and other locations. For smaller switchgear, plug-selection is satisfactory, as are transfer circuit breakers. Single 'bus-bar arrangements will, however, meet the majority of requirements and therefore appear to be the right choice for future designs, particularly for secondary distribution stations. It is doubtful whether a ring 'bus-bar is ever justified for this application of switchgear because the number of outgoing feeders is usually far greater than the proportion required for flexible operation.

At the present time, metal-clad switchgear up to 66 kV has been supplied with a variety of insulating media, the choice being largely determined by the voltage, type of construction and application. The great majority of single or double 'bus-bar metal-clad switchgear panels up to 33 kV have compound and oil as the insulating medium. At 33 kV there is some specially-constructed generating station switchgear with Freon or air as the insulating medium, except that the circuit breakers are oil filled. At 66 kV, oil filling is preferred at the present stage of development. Opinions vary on the degree of phase separation necessary with open or metal-clad switchgear. In some metal-clad switchgear complete phase separation by earthed metal is provided and the remainder have partial phase separation. As far as high-voltage outdoor open-type circuit breakers are concerned, the modern dead-tank bulk-oil-volume type, with arc control and individual plunger bars and operating rods, appears to be quite satisfactory without earthed metal phase separation. This would result in there being three phases in one tank, a practice already adopted by one manufacturer in Canada at 138 kV. For main generating stations, 33-kV or 66-kV metal-clad switchgear, it is usual to specify complete phase separation. For other switchgear, practice varies considerably and whether phase separation is adopted or not depends upon such factors as the duty, the voltage, the filling medium, the kind of protection provided, the possibility of damage from open arcing or from fire and the magnitude of the short-circuit current.

The choice between internal (oil-immersed or air) isolation with a fixed or removable circuit breaker and a removable circuit breaker with air-insulated plug-and-orifice isolation for metal-clad indoor switchgear seems to depend largely on the voltage and application. For switchgear up to 33 kV, and when the size of the circuit breaker makes it easy to handle, isolation by moving the circuit breaker is preferred. The advantages of plug-and-orifice isolation are that it is simple, that it is possible to see positively that the unit is completely isolated, and that generally it involves little maintenance. In 33-kV and 66-kV generating stations, where the circuit breakers become difficult to handle owing to their size, self-contained isolation is sometimes preferred. This has also much to recommend it for switchgear in very humid atmospheres. The questions involved in a comparison between vertical and horizontal isolation for metal-clad switchgear with air orifices are very controversial. The authors, however, conclude that each type has advantages for particular applications, but that for medium and large switchgear vertical drop-down isolation is preferable if only a single 'bus-bar is required, owing to the smaller space requirements and neater appearance. On the other hand, when double 'bus-bars are required horizontal draw-out isolation is preferable, owing to its compactness and the ease with which 'bus-bar selection is obtainable in various ways. For small switchgear, the horizontal single 'bus-bar and pillar type is more economical and gives better maintenance facilities. In fact, it appears to be almost universally adopted.

Turning to circuit breakers, three types are in common use abroad on 220/264-kV outdoor open type switchgear, namely, the dead-tank bulk-oil-volume circuit breaker, the live-tank small-oil-volume circuit breaker, and the air-blast circuit breaker. Each type has its own advantages and applications, and standardisation of a particular pattern does not therefore arise. The development, research and testing of equipment at this high voltage is very expensive and is responsible for a considerable proportion of the cost. Further, research and test equipment will probably have to be capable of extension to deal with 400-kV switchgear. It is obvious, therefore, that the total demand will not justify many manufacturers entering this field. In any event, communal research and testing facilities should be made available.

All the three types of circuit breakers just mentioned are also in common use at 110/132 kV. In America the tendency seems to be to concentrate on bulk-oil-volume circuit breakers, whereas on the Continent small-oil-volume and air-blast circuit breakers appear to be equally popular. Bulk-oil-volume circuit breakers manufactured in Great Britain for this range of voltage have given good results in service for many years. They are complete with current transformers and in their latest form are suitable for high-speed automatic re-closing. Their performance on short-circuit is almost equal to that of other types and at their present stage of development they tend to be the cheapest. Inspection and maintenance, however, are lengthy and troublesome, involving expensive separate oil-handling equipment; and they are not suitable for use indoors because of their size and the large volumes of oil. In their latest form, small-oil-volume circuit breakers for 110/132 kV have an extremely good performance on short-circuit. They are very suitable for high-speed automatic re-closing; inspection maintenance and oil changing can be quickly effected; and they are also suitable for use indoors owing to the reduced oil volume. Further, they are more easily adaptable than bulk-oil-volume circuit breakers to non-standard voltages, and service experience with them has been extremely good.

Probably the outstanding features of air-blast circuit breakers for 110/132 kV are good performance on short-circuit and ability to deal with a large number of faults without maintenance. A further advantage claimed for them, when they comprise two or more unit circuit-breaking heads, is that one unit can be tested and the performance of the complete circuit breaker assessed from the results. At the present stage of development, manufacturing costs tend to be high, the high-speed series-break switch cannot be considered an ideal piece of equipment and high-speed automatic re-closing is usually more costly and complicated than in other types. If current transformers are required on both sides of the circuit breaker the cost is further increased.

In these three types of circuit breaker, standardisation is difficult other than in relation to some common auxiliary equipment and neither the user nor the manufacturer is clear about the type upon which he should concentrate. Even though standardisation is not possible, the number of types and different designs of the same type could be much reduced and the first step seems to be some form of rationalisation of research, development and manufacture so that selected designs may receive more attention.

The same general comments apply to 66-kV outdoor open-type switchgear as to that for 110/132 kV, except that the number of MVA breaking capacity ratings is greater and that two patterns of bulk-oil-volume switchgear are in common use. Even although the demand for switchgear at this voltage is large, some measure of rationalisation would seem to be both desirable and feasible. At 33 kV, practice in this type of switchgear varies considerably, all the three types of circuit breaker mentioned above being available. At the present stage of development, however, neither small-oil-volume, nor air-blast circuit breakers appear to be competitive at the lower MVA ratings; and the bulk-oil-volume circuit breaker, because of its lower cost, its simplicity and the fact that it is completely self-contained should therefore be standardised with three phases in one tank. Spring closing (which can be either hand or motor recharged) is preferable and accommodation for current transformers should be provided on both sides of the circuit breakers.

(To be continued.)

HINTS FOR COMMERCIAL VISITORS TO FINLAND.—Finland has now been included in the series of "Hints to Business Men" booklets issued by the Export Promotion Department of the Board of Trade. Applications for copies should be sent to the Department, 35, Old Queen-street, London, S.W.1.

RAILWAY ELECTRIFICATION IN PORTUGAL.—An order for the supply of rolling stock for use on the line between Lisbon and Cascais at the mouth of the Tagus has been received from the Sociedade Estoril by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. The contract includes both motor and trailer coaches, the mechanical parts of which will be constructed by Cravens Railway Carriage and Wagon Company, Limited, Sheffield, as well as a locomotive, which is to be built by the North British Locomotive Company, Limited, Glasgow. Both types of coach will be mounted on two two-axle bogies; and the motor coaches will be equipped with four 140-h.p. self-ventilated direct-current motors, which will be electro-pneumatically controlled. The locomotive will also be of the double-bogie type, each axle being equipped with 240 h.p. 1,500-volt forced-ventilation motors. It will be capable of hauling 240-ton passenger or 600-ton goods trains at speeds up to the permissible maximum of 50 m.p.h.

CATALOGUES.

Gas-Fired Infra-Red Heating Units.—Messrs. Parkinson and Cowan (Gas Meters), Limited, Engineering Division, Cottage-lane, City-road, London, E.C.1, have sent us a publication giving technical particulars, dimensions and typical applications of their gas-heated tunnel units for infra-red heating.

Metal Powders for Welding Electrodes.—A leaflet dealing with metal powders for welding-electrode manufacture, which is available in French and Spanish, as well as in English, has been prepared and issued by Murex Limited, Rainham, Essex. The range of purity and the main uses are among the data given for each powder.

Anti-Friction Metal.—A booklet on their Eel-brand nickel-hardened anti-friction metal has been issued by Murex Limited, Rainham, Essex. Particulars of physical properties, casting procedure and other matters are given, and the firm add that the material has been accepted by Lloyd's Register of Shipping for use in the bearings of machinery intended for vessels classed by the Society.

Specifications for Aluminium.—A new edition of their booklet, "Specifications for Aluminium and Aluminium-Alloy Products," has been published recently by the Northern Aluminium Company, Limited, Banbury, Oxfordshire. It contains tables of B.S./S.T.A., B.S. and D.T.D. specifications for sheet, strip, bars, wire, rivets, forgings and castings, an index to proprietary names, and other useful information.

Industrial Furnaces.—Messrs. Stein and Atkinson, Limited, Parnell House, 25, Wilton-road, London, S.W.1, have sent us a well-illustrated publication giving particulars regarding their "Rust" continuous furnaces, one-way fired "Surface" soaking pits, heat-treatment furnaces of various types, radiant-tube and radiant-burner annealing furnaces, rotary melting furnaces, Chapman gas producers, glass tank furnaces and lehrs, suspended furnace arches and walls, and Hagan stokers for industrial furnaces.

Pocket Light Tester.—A catalogue issued by Messrs. Ferranti, Limited, Hollinwood, Lancashire, describes a new instrument for the measurement of lighting values. It consists essentially of a selenium photo-electric cell and a sensitive moving-coil movement; and is provided with two ranges, 0 to 60 foot-candles and 0 to 300 foot-candles; the second of which is obtained by clipping a shield over the cell. Generally speaking, the instrument complies with B.S. 667-1945 for photo-electric type photometers.

Special Steels.—Two brochures have been issued by Messrs. Colvilles Limited, 195, West George-street, Glasgow, C.2, the first dealing with their "Colmo" creep-resisting steels for high-temperature service, and the other with their stainless-clad steels. The former contains particulars of steels for use at temperatures of from 800 deg. F. to 1,000 deg. F., while the other describes the firm's "Colclad" composite plate consisting of a commercial-quality steel plate bonded, on one side, to a veneer or "cladding" of corrosion-resisting steel.

Centrifugal Switches.—A range of centrifugal switches, which have been designed for use with two-, four- or six-pole single-phase, 50-cycle motors with outputs up to 1½ h.p., is dealt with in a pamphlet issued by The Pleasey Company, Limited, Ilford, Essex. These switches consist of two parts, one of which is mounted on the rotor and the other on the stator end shield. When the speed of the motor reaches from 72 to 82 per cent. of its synchronous speed, the rotor portion expands radially and engages with a tongue on the stator portion. As a result, the switch is opened and the motor starting winding disconnected. When the motor is switched off and slows down, the contraction of the rotor portion re-sets the switch for the next start.

Resistance-Capacitance Oscillators.—The latest issue of *Technique*, which is published quarterly by Messrs. Muirhead and Company, Limited, Beckenham, Kent, is dated July, 1947, but has only just been received. It is entirely devoted to a paper by Messrs. E. R. Wigan and J. A. B. Davidson on the principles of design and practical development of the decade oscillator. The operational advantages of this apparatus will be dealt with in a later issue. The decade oscillator is the result of 14 years' development, which dates from 1934 when P. W. Willans started work on a resistance-capacitance oscillator of the three-phase type, such as that described by van der Pol. These oscillators, however, possessed the disadvantage of having three variables which had to be operated simultaneously. Later, two-element network oscillators were devised. These were followed by the first commercial resistance-capacitance oscillator, which was manufactured by the company and had a continuously variable range from 20 cycles to 20 kilocycles per second. From this instrument decade tuning, which makes the tuning network independent of the output impedance of the maintaining amplifier, has been developed.

LABOUR NOTES.

THE part of the Government's "Economic Survey for 1948" which will give most concern to the trade unions is the suggestion that half a million men must leave their present jobs and find employment in other industries the activities of which are officially deemed to be essential to the success of our economic recovery plans. Compulsion on men and women to "switch over" is not contemplated. "The Government," it is declared, "can encourage, it cannot compel." As both the Survey and the White Paper on "Wages, Profits and Prices" are certain to be discussed at next week's conference of executives as well as later at the annual conference of the Labour Party, it is to take a considerable risk to attempt to predict what the reaction will be to the suggested "switch over." It is not, however, to take any risk at all to say that the "switch over", as contemplated, will not increase output to any immediate appreciable extent as the 500,000, or so, switched workers are not the equal, in respect of technical skill or experience, of those whose jobs they may be "directed" to take.

Most of the resolutions which have been sent in for discussion at the Whitsuntide annual conference of the Labour Party at Scarborough naturally express the opinions of local labour parties, but at least three important trade unions are represented in the preliminary agenda by motions which do not, strictly speaking, deal directly with trade-union affairs. The Transport and General Workers Union proposes to move that "this conference views with grave concern the increase in commodity prices. . . . It feels that rising prices cannot be justified, particularly having regard to the increases in profits or revealed in the public returns of trading and manufacturing companies. This conference is not convinced that profits can be effectively controlled by a mere reliance on voluntary efforts on the part of manufacturing and trading organisations. It, therefore, calls upon the Government to take such action as will curb exorbitant profit distribution."

The National Union of Mineworkers calls on the conference to declare its loyal support for the Government, and to endorse its home and foreign policy, welcoming the Marshall offer and the recent trade pacts with Russia and other European countries. The Amalgamated Engineering Union expresses dissatisfaction with the type of person appointed to the boards controlling nationalised industries. Judging from the text of their resolutions, several local labour parties are of much the same opinion. Two of the latter bodies claim that the salaries paid are too large.

Returns received at the head office from branch secretaries indicate that at the end of February, the membership of the Amalgamated Engineering Union was 809,614—an increase of 10,082 compared with the position at the end of January. During February, 6,562 members received sick benefit—an increase of 479—20,167 members superannuation payments—an increase of 40—and 1,270 members unemployment benefit—an increase of 174. The total number of unemployed members was 3,320—an increase of 383.

Most of the space devoted to editorial notes in the March issue of the Amalgamated Engineering Union's *Journal* is occupied by references to the statement on the subject of wages circulated to affiliated unions by the General Council of the Trades Union Congress. "When," the writer says, "the special conference of trade union executives meets on March 24 . . . it will have to decide whether it shares the General Council's view of the White Paper, and . . . agrees to guide union action accordingly. The union executives, as a whole, will undoubtedly be influenced by the credit they can give to the Government's resolve to deal adequately with prices and profits. The General Council in their consideration of this aspect of the problem places the maximum reliance upon the statement made in the House of Commons by the Chancellor of the Exchequer. Sir Stafford Cripps told the House that he has called upon the Federation of British Industries, chambers of commerce, and other responsible and influential organisations concerned with industry and trade to furnish within one month proposals for stabilising profits and prices."

"Sir Stafford also informed the House that he had told these bodies that the most effective way in which they could help the country in its present difficulties is to reduce profits and reduce prices, and indicated quite clearly that if this was not done voluntarily, he held the weapon of the Budget in reserve as a means of enforcing control of prices and profits. The T.U.C. has made not merely stabilisation of profits and prices, but a reduction in both, a condition of their recommendation to the affiliated unions. . . . At this stage of the discussion, we will not, in these notes, venture a prediction of how the unions will react to the General Council's recommendation. We do feel, however, that every trade unionist should try, calmly and dispassionately, to keep a clear mind on the problem. A good deal of propaganda has been unleashed against the T.U.C's handling of the wages question. Some of this propaganda . . . comes from those who want the trade unions to be ordered to make no more wage claims. Other propaganda is coming from those who want the trade unions to disregard every other consideration but the claims of the wage earners to higher wages. Between these cross-fires, the T.U.C. has tried to keep a balanced view and to advise the unions how to guide their action in the present circumstances of great difficulty and danger."

Under a decision of the National Joint Industrial Council for the electricity-supply industry, wages are increased, as from this week, by 5*s*. 6*d*. a week. The new rates for a 44-hour week range from 2*s*. 3½*d*. an hour to 2*s*. 9½*d*. an hour in provincial areas. London rates are appreciably higher. The new agreement applies to all grades of employees employed in the generating, transmission and distribution sides of the electricity-supply industry, and the parties to it include the National Union of Engineers and Firemen, the Amalgamated Engineering Union, the Electrical Trades Union, the National Union of General and Municipal Workers, and the Transport and General Workers Union.

An agreement reached between British Railways and the three unions of railwaymen provides for wage increases ranging from 26*s*. to more than 100*l*. a year in the wages of supervisory and clerical, and upper grade employees. Lower grade persons, such as porters, are excluded from the scope of the agreement. Supervisory personnel, such as shedmasters, receive increases of more than 100*l*. a year, clerical staff between 7*l*. 10*s*. and 50*l*. a year, and upper grade employees between 26*s*. and 7*l*. 10*s*. a year. Guards receive from 2*s*. to 5*s*. more a week, station foremen 6*s*., drivers 4*s*., firemen 3*s*., and ticket collectors 4*s*. 6*d*. The position of shopmen is left over for further consideration.

At a meeting in Blackburn attended by delegates from the trade unions in the cotton trade and addressed by Mr. Ness Edwards, the Parliamentary Secretary to the Ministry of Labour and National Service, a resolution was adopted urging operatives in the industry to resume overtime working for 2½ hours a week as an immediate contribution to Britain's economic revival. Mr. A. Naesmith, secretary of the Amalgamated Weavers' Association, who moved the resolution, stated after the meeting that immediate steps would be taken to give effect to the resolution.

Official figures relating to the coal-mining industry indicate that in the week which ended on February 28, voluntary absenteeism among colliers at the coal face was 7·88 per cent. compared with 7·62 per cent. in the previous week and 11·34 per cent. at March 1, 1947. Output per man-shift at the coalface was 2·92 tons in the week which ended on February 28—this was the same as for the previous week and it compared with 2·75 tons a year ago.

In the industries covered by the statistics regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reputed to have come into operation in the United Kingdom during January resulted in an aggregate increase estimated at approximately 100,000*l*. in the weekly full-time wages of about 320,000 workpeople. In addition, a number of workpeople had their hourly rates increased, so as to give approximately the same weekly wages as before for a shorter working week. The principal groups of workpeople affected were engaged in the cotton-spinning industry, the manufacture of boots and shoes, a section of the heavy-chemicals industry, certain sections of the printing industry, and leather production.

The changes in hours of labour reported to have come into operation in January resulted in an average reduction of about 3¾ hours a week for about 96,000 workpeople. The principal groups affected were workpeople in the brick-manufacturing industry, whose working week was reduced from 48 hours to 44; in stamped and pressed-metal ware manufacture, whose working week was reduced from 47 hours to 44; in the production of ballast, sand, and gravel aggregates whose working week was reduced from 48 hours averaged over the year to 44 hours throughout the year; and maintenance men, warehousemen, or other shore employees (excluding lock-keepers and persons with irregular working hours) in inland waterways in England, whose working week was reduced from 48 or 47 hours to 44.

FORTY YEARS OF THE INSTITUTE OF METALS.*

AT this, the 40th annual general meeting of the Institute of Metals, it would appear opportune to re-examine the reasons which led to its establishment, the ideals its founders had in mind, and the principal objects which they intended it to fulfil. The Institute of Metals was founded 40 years ago, after lengthy deliberations and many natural fears. The germ of the idea came from a young engineer named Walter H. A. Robertson who, in a letter dated January 20, 1908, directed the attention of the Editor of ENGINEERING to the long-felt desire of progressive manufacturers "for an Institution of a similar kind to that valuable organisation possessed by the Iron and Steel Traders." The idea was quickly taken up, and Mr. W. H. A. Robertson, whom I am pleased to see present here this morning, may justly claim to be the initiator of the movement which led to the formation of our Institute.

A preliminary meeting of those interested was held in Manchester on March 10, 1908. Manchester, however, is proverbially a cautious City, and our forebears in the non-ferrous metals industry were cautious men; in consequence, as the proposal was then only some eight weeks old, those present were in favour of going slowly. When the Iron and Steel Institute was mooted in the early 'sixties, had not the founders allowed six months for the idea to germinate? The Victorians and the early Edwardians were not accustomed to rush their fences. The House of Commons of those days did not pride itself on crashing through legislation that would change the whole life and habits of the British people in a couple of all-night sittings. So those present at the Manchester meeting went away to think things over, and it was not until the adjourned meeting, held in London on June 10, 1908, that the all-important decision was taken. This cautious approach was just as well, for we might have been saddled with the trivial and most clumsy title of "The Copper and Brass Institute," which was at one time proposed.

There appears to have been a fear in the minds of the speakers at Manchester that the new Institute might fail through the supposed disinclination of the all-powerful manufacturers to allow their technical people to contribute papers or to take part in the discussions. For example, in 1908, as a student-apprentice, my employers discouraged me from joining the new body for fear competitors would extract from my young and, I hope, receptive mind some of the so-called "trade secrets," into the mysteries of which I was being initiated. Commenting on this "trade secret" complex, *The Ironmonger*, in its issue of March 14, 1908, said "The trouble in connection with 'trade secrets' will cure itself as time goes on." How prophetic! "All but the most obtuse," continued *The Ironmonger*, "must soon be convinced that the net result of the Institute's work will be beneficial to the industry as a whole. There will no doubt always be some who will cling to a secret process, but as a general rule these will be men whose secrets are the least worth preserving." How true!

The *Manchester Guardian* of March 11, 1908, which reported the meeting of the previous day, makes interesting reading in 1948. The man who advocated caution and further consideration was Rosenhain—of all men! Indeed, he framed and moved the resolution advocating the desirability of a later meeting before a definite constitution was framed. It is interesting, too, to find that neither Robertson, who gave the first impulse to the movement, nor Rosenhain was a member of the first Council. In addition to Sir William White, whose presidential address was a masterpiece of clear and concise English, setting forth the objects of the Institute and its ideals, there were, among others, on the first Council, such men as Norman Cookson, Gowland, Gerard Muntz, Engineer Vice-Admiral Oram, Thomas Turner, Boeddicker, Tom Bayliss, Carpenter, Nisbett and Dr. R. S. Hutton, and we should not overlook the pioneer work of W. H. Johnson, of Manchester, the first honorary secretary. I would also make reference to Shaw-Scott, Birmingham's first graduate in metallurgy, who was our first secretary and editor, and to whose guidance and devotion we owe so much.

The papers read at the opening meeting in Birmingham, in November, 1908, make most interesting and informative reading, even to-day. J. T. Milton, the chief engineer surveyor of Lloyd's Register of Shipping, gave his experience as a user of copper and copper alloys; Bengough and Hudson—who were to leave their mark on the industry over the years to come—discussed the mechanism of annealing copper alloys; Echevarri spoke of aluminium and its uses, and referred to the enormous demand for aluminium in 1906 and 1907. The word "enormous" related to the world production of 15,000 tons and 23,600 tons, respectively. Little could he have dreamed of the 1,890,000 tons produced at the peak of the war usage; a hundred-fold increase during the life-time of this Institute. Arnold Phillips, the Admiralty chemist, related the experience of the Navy with phosphor-bronze. Walter Rosenhain, who had just taken charge of the metallurgical department of the National Physical Laboratory, made the first of what the President hoped would be "a series of communications based on the work done there"—a hope well founded. C. H. Desch, who at that time was engaged in writing one of the pioneer text-books on metallography, gave a contribution on "Inter-Metallic Compounds" which presented, in concise form, much valuable research work in a field quite unexplored by the average member of those days, and in a language that was "double-dutch" to the manufacturers and also, I expect, to many of the technicians. And so, to give the poor Birmingham manufacturer a chance to come down to earth after the learned discourses of Rosenhain and Desch, Walter Robertson wound up the meeting with a characteristically practical paper on the manufacture of tubes. Norman Cookson concluded the discussion with the comment that "the research man should stick to his last," because "he would be doing very much more good in that way than in attempting to solve manufacturing difficulties in the application of his ideas." I quote him because his words epitomise the manufacturers' attitude towards science and research in those days.

What of the future? What is the role of the Institute of Metals; what part can it best play to-day in the development of the art and science of metallurgy? Progress in all branches of learning is largely dependent on the full interchange of knowledge among workers pursuing similar lines of study. Metallurgy is an old art and a new science. As a director of a large company, whose metallurgical interests, though the largest in Europe, are small by comparison with its chemical interests, I am perhaps in the unique position of being able to contrast the two industries, and particularly the scientific approach and the works technique characteristic of them.

It is the duty of those of us engaged on the industrial side to make a continually improved product, at a continually reduced cost of production, available to the user, and, through him, to the general public, passing on to the ultimate consumer most of the benefits to be derived thereby. This is the means by which the standard of living can be permanently raised. How is this to be done? I believe the important factor is "continuity of production," and here I cannot help but contrast works processes as carried out in the chemical industry with those in the metallurgical field. The great chemical industry is essentially based on continuous processes, operating 365 days a year, 24 hours a day. The manufacturing metallurgist and the user work, in the main, on batch processes, nowadays operating a five-day week; it is no wonder, therefore, that capital investment per ton-year plays so large a part in our considerations. Up to now, we have striven to combat this by speeding up motors, rolling mills, wire-drawing machines, presses, etc., and, as metallurgists, we have solved the problem of materials which will stand up to these increased demands; but I suggest that this is merely toying with the problem.

The best method of increasing production and obtaining the maximum return from the capital employed is the decrease, or the complete elimination, of "idle time," rather than in trying to increase speed *per se*. It is self-evident that, if metallurgical plants must start, operate, and stop, not only will the efficiency of the plant be increased by eliminating the starting, stopping, and stand-still time, but the resultant product will be greatly improved if it is produced by a continuously uniform operation. Its cost, too, will be lessened, even if the actual speed of the machine when operating continuously is lower than the speed of the machine in the first instance. This question of elimination of idle time is, I suggest, a major lesson that the metals industry can learn from the industrial chemist. Admittedly, the industrial metallurgist can point with pride to the improvements made in production processes by continuous methods of casting, the so-called continuous rolling of tandem mills, and continuous wire-drawing technique, etc. All of these are developments of recent years, but the fact remains that continuity of operations is not a strong feature of the metals industry generally. We are a "batch process" industry, and to any industrial metallurgist laying out a new plant I would commend the technical approach of the industrial chemist as worthy of close consideration. There is much to learn.

The metallurgical industry is as old as Tubal Cain himself, whereas, as Hume-Rothery* has pointed out, "much of the chemical industry of to-day is a large-scale development of previous laboratory research and the industry has developed after the main principles of chemistry have been established." On the other hand, metallurgists always seem to be trying to explain things which have been practised over many years; we are attempting to superimpose a science on an old-established art. This gives rise to its own peculiar and special problems, both in research and in works practice. We of the Institute of Metals are trying to collect facts, to analyse them, and to interpret them in terms of works technique. The proper collection of these facts is the stepping stone to future knowledge and the permanent aid to generations of workers yet unborn. And so, although I belong most definitely to the school of industrial metallurgists—those who are trying to apply and adapt scientific knowledge to works practice—I would plead with members to encourage those who are engaged on investigations which may at present possibly be of little or no commercial value, but are calculated to establish the underlying general principles of the science of metallurgy. It is no exaggeration to say that the whole of our vast chemical industry, both inorganic and organic, is based on principles revealed only as the result of arduous work on substances originally of academic interest only.

"It should be appreciated," continues Hume-Rothery, "that, scientifically, there is nothing more improbable in the idea of building up an alloy of desired properties from a knowledge of the characteristics of the different kinds of atoms, than there is in building up synthetic dyestuffs with desired colours. The difference between the two problems lies, largely, in the fact that whereas the dyestuff chemist works with a soundly established science behind him, in physical metallurgy the general principles are only just being revealed." Metallurgy, too, is not without its parallels. Most modern non-ferrous alloys have been built up deliberately, not as the result of numerous trials and errors as in the past, but on general scientific principles, well established by investigators in the so-called academic field. The aluminium light alloy which formed the basis of our aircraft construction programme is a practical instance. The progress of all science is essentially cumulative; we build on the foundations established by our predecessors. This Institute is a learned society, not a research association. We exist to collect facts, to exchange ideas, to disseminate and record new knowledge, and to build up works technique and user practice on the information and experience thus acquired. It is all the more important, therefore, that those who are concerned with the practical application of metallurgy should encourage on every hand those who are engaged in seeking new knowledge, and should see that every possible step is taken speedily and scientifically to adapt this knowledge to industry.

That is not always quite so easy as it may appear at first sight; as Barclay pointed out in his presidential address in 1936, works' practices are necessarily complex. They embrace such factors as the impact and reaction of labour, economic conditions, financial considerations, etc., whereas, as Rosenhain has stated,* the scientific investigator rightly endeavours to simplify his conditions so far as possible. "How" is generally a much more complex problem than "why." When I was younger, I had the firm conviction that the higher management was singularly unappreciative of things that seemed to me to matter so much. Since I myself have reached that estate, I am inclined to believe that my earlier convictions were not entirely ill-founded, but, on the other hand, I now realise that higher management is faced with problems which are, in many ways, far more difficult than those of the research worker and the technician.

There have been complaints that the Institute has not published more so-called "practical" papers, but the remedy lies entirely in the hands of the members themselves. I do not think we can complain any longer of the reticence of management to permit the publication of such matter dealing with works technique. In an endeavour to adjust the balance, it is the Council's intention that, in 1949, a whole day shall be devoted to a symposium or general discussion on metallurgical aspects of non-ferrous metal melting and the casting of ingots for working. It is hoped that this experiment will lead to a regular series of critical examinations of various aspects of works practices. During the past 40 years, the Institute's literature is rich in good sound thinking and in the study of basic fundamental work. The time has now come, and, indeed, is overdue, when, to assist in the production of better materials at competitive costs or the same materials at lesser costs, we should give equal thought and prominence to the practical application of this fundamental knowledge. This is surely one of the Institute's proper functions in relation to our industry, and one which our founders certainly had in mind. The non-ferrous metals industry, for which this Institute stands as the accredited learned society, covers a wide field; but, fortunately, the knowledge acquired, collected and disseminated by the Institute is capable of application over an equally wide, if not wider, field.

* Presidential Address to the Institute of Metals by Sir Arthur Smout, J.P., delivered at the Institution of Civil Engineers, Great George-street, London, S.W.1, on Wednesday, March 17, 1948. Abridged.

* "Researches on the Structure of Alloys," *British Non-Ferrous Metals Research Association Report No. 562.*

* *Jl. West of Scotland Iron and Steel Inst.*, 1915-16.

TORSIONAL-FATIGUE TESTS OF MARINE SHAFTING.

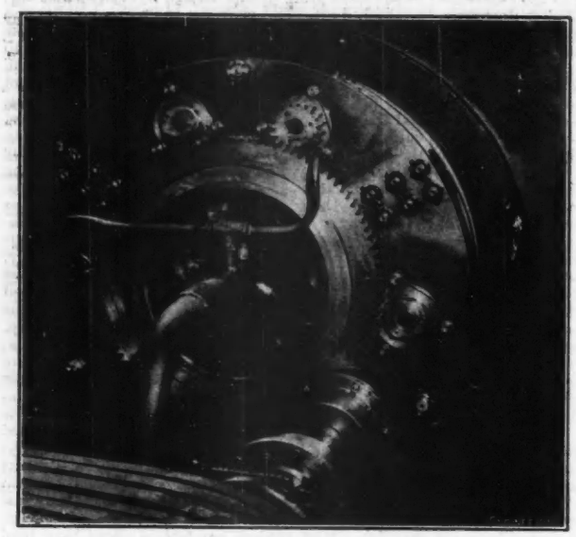
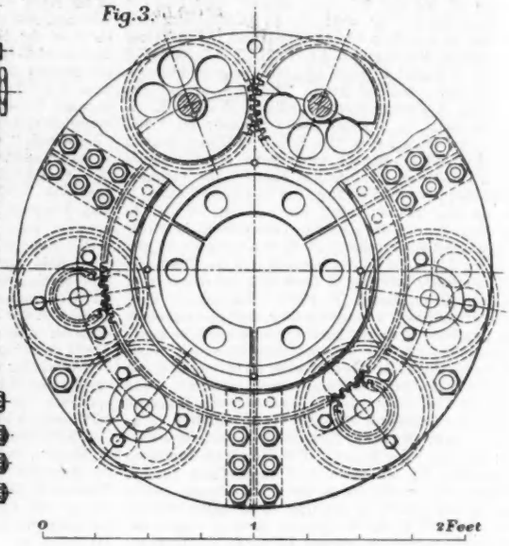
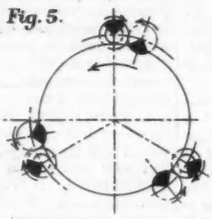
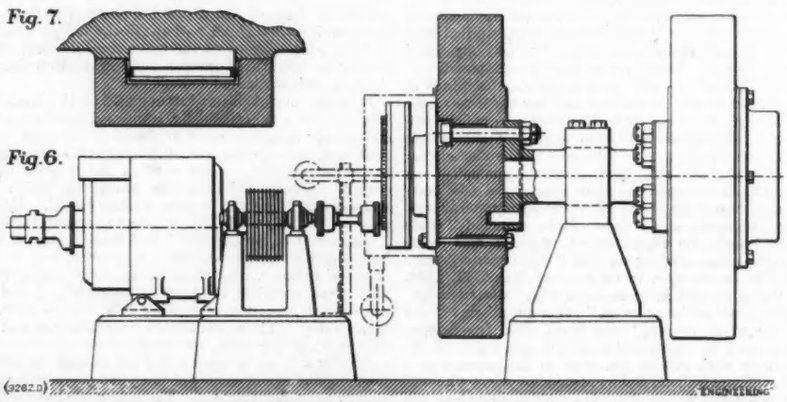


FIG. 1. TORSIONAL-VIBRATION EXCITER.







TORSIONAL-FATIGUE TESTING OF MARINE SHAFTING.*

By S. F. DOREY, C.B.E., D.Sc., Wh.Ex.

It has been known for many years that when a material is tested under fluctuating stress conditions the size of the test piece may have some effect on the endurance limit. In general, however, comparisons have been made, in the case of torsional tests, between specimens varying in diameter from 0·25 in. to 2 in. The results of a few tests relating to specimens 3 in. in diameter have been published, but above this size extremely limited information is available. This is mainly due to the cost involved in building a machine, together with the cost of the specimens, and, in respect of alternating torsional-fatigue testing machines, the amount of power necessary to drive the machines. The latter difficulty can, however, be overcome by designing a machine so that the specimen can be stressed by making it serve as the spring member in a mass-elastic system, and vibrating it torsionally at, or near, the natural frequency of the system. The machine to be described in this paper has been designed by employing this principle and a special design of torque exciter to induce the alternating torsional stress in the specimen.

Stresses causing failure of large mild-steel marine shafts appear to be appreciably less than those obtained with test specimens of about 0·3 to 0·5 in. diameter, and allowing for the effect of stress "raisers" (for example, fillets, keyways, lubricating holes, and notches).† In the majority of cases, shaft failure was known to be caused by excessive torsional vibration stresses, and a knowledge of the true fatigue strength of large forged shafts was required for the assessment of the vibration stresses (arising during both transient and continuous operation) which permitted a reasonable life. In addition, a knowledge of the reduction of fatigue strength due to fillet radii, oil holes, keyways, and "knifing" of coupling-bolt holes was necessary.

Impetus for this large-scale fatigue testing was given during the war by the Admiralty, and arose from a proposal to use thick solid-drawn steel tubes—approximately 10 in. diameter and 6 in. bore, with flanges welded on—in place of forged shafts. Before adopting this type of shafting, however, it was considered desirable that fatigue tests should be carried out on full-size specimens. At about this time, a new type of torsional vibration damper and torque exciter had been designed and patented by Dr. G. H. Forsyth, while he was in charge of engineering research at Lloyd's Register of Shipping. The first of its kind had been made by Messrs. W. H. Allen, Sons and Company, Limited, Bedford, to the order of Messrs. The Wellman Bibby Company, Limited, for fitting into an oil-engined vessel. The ship was sunk, however, before the damper could be fitted, and it was decided to use the latter as a torque exciter in the construction of a large torsional-fatigue testing machine.

Figs. 2 and 3 show details of the torsional-vibration exciter, and a photograph of it is reproduced in Fig. 1. It consists of two plates bolted rigidly together, forming a cage. Between the two plates are mounted three

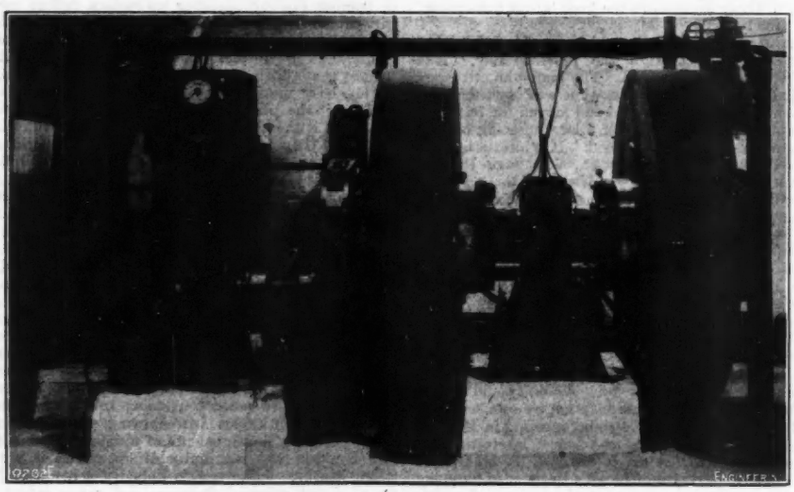


FIG. 8. TESTING MILD-STEEL SHAFT.

* Paper read before the Institution of Mechanical Engineers, London, on Friday, February 13, 1948.

† "Strength of Marine Engine Shafting," by S. F. Dorey. *Trans. North East Coast Inst. Eng. and Shipbuilders*, vol. 55, page 203, (1938-9). See also ENGINEERING, vol. 147, page 563 (1939).

FATIGUE TESTS OF MARINE SHAFTING.

Fig. 9.

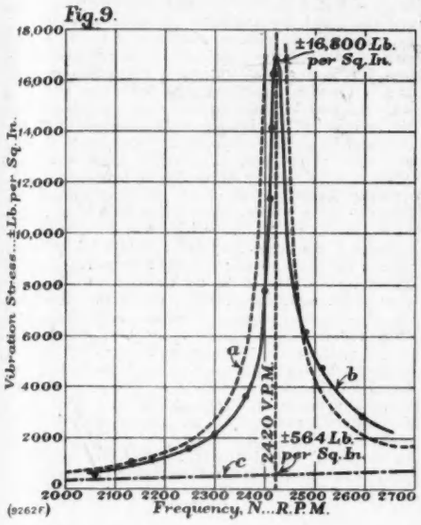


Fig. 10.

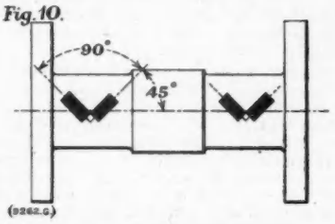


Fig. 11.

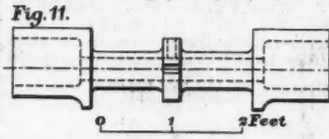


Fig. 12.

Fig. 13.

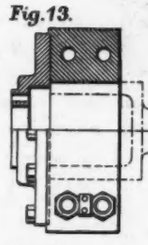


Fig. 14.

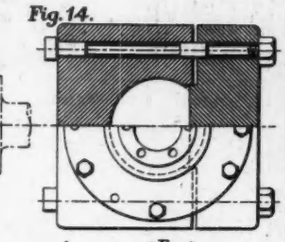


Fig. 15.

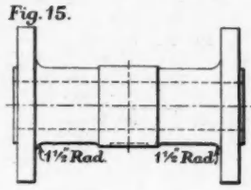


Fig. 16.

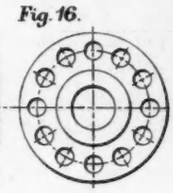


Fig. 17.

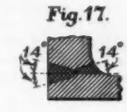


Fig. 18.

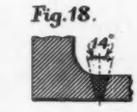


Fig. 19.

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FIG. 20. FATIGUE CRACKS IN SHAFT NO. 4.

FIG. 21. FATIGUE CRACKS IN SHAFT NO. 5.

pairs of meshed out-of-balance wheels, one wheel in each pair being rigidly connected to a planet pinion meshing, in turn, with a sun-wheel mounted on the outside of the cage. The three pairs of planets are arranged symmetrically in the cage at intervals of 120 deg., and, by suitable phasing, the six meshed out-of-balance wheels develop maximum torque at the same instant, as shown in Figs. 4 and 5, opposite; moreover, the radial components of the centrifugal forces are in balance at all times. For the exciter used in the testing machine, the maximum forcing torque is given by

$$T = 0{\cdot}0146\,N^2\,\text{lb.-in.} \qquad . \quad (1)$$

at N r.p.m. of the planet pinions, the W r per planet being 8·37 lb.-in., and the orbital radius of each planet being 10¼ in. The torque exciter is applied to a stationary shaft, but it can equally well be applied to a rotating shaft.

Figs. 6, 7 and 8, opposite, show the arrangement adopted for testing mild-steel shafts. The test piece forms a short bobbin shaft mounted in a central pedestal bearing, the test portions being 9¼-in. outside diameter, and 6¼-in. inside diameter. After some consideration, a length of about 2 ft. between flanges was decided upon, having regard to economy of space and the weight of the test piece. The calculated torsional stiffness of the shaft is 350×10^6 lb.-in. per radian twist. In order to eliminate the transmission of vibration to the foundations of the machine, a two-mass torsional system has been adopted, by bolting a heavy cast-iron flywheel to each of the flanges of the test shaft, and the machine is run as closely as necessary to the resonant frequency of the system, the exciter cage being rigidly attached to one of the flywheels, and a counter-balance weight, equal to that of the exciter, bolted to the other flywheel. The flywheels are 5 ft. in diameter by 12 in. thick, and weigh approximately 4 tons each. Fig. 1 shows the drive to one of the pinion shafts, which, by rotating the sun-wheel, drives the remaining pinions. The drive embodies a cardan shaft with flexible couplings at each end. With this arrangement, the pinion can vibrate freely, torsionally about its own axis, and laterally as a result of the torsional displacement of the test specimens. The remaining part of the drive is through a nine-strand Tex rope from a 30-h.p. shunt-wound direct-current motor. The shaft speeds of the planet pinions and of the motor are 2,500 r.p.m. (nominal) and 1,200 r.p.m. (nominal), respectively.

The mass-elastic system formed by the two flywheels and the test shaft was designed for a natural frequency of about 2,500 vibrations per minute. The test shaft is supported at the nodal point corresponding to resonance. Difficulty was envisaged with the pedestal bearing, on account of frettage corrosion and excessive vibration transmitted to the foundations before resonance was reached. Furthermore, vibratory energy had to be transmitted through this bearing to the flywheel remote from the exciter. Accordingly, for the initial tests, the key in the central journal was provided with a measure of torsional flexibility by means of a rubber ring arranged in a groove, the keyway in the cast-iron pedestal bearing being given adequate clearance, as shown in Fig. 7. Frettage corrosion has been largely eliminated by arranging rubber sealing rings in circumferential grooves at each end of the pedestal bearing, the bearing clearances being pumped solid with zinc-oxide grease. The latest practice, however, has been to use a solid key, bearing on a flat milled in the shaft journal, which arrangement has proved entirely satisfactory, with no appreciable vibration of the pedestal bearing. It should be mentioned that the bearing is very slightly tapered on the lower half on both sides from the centre, leaving an effective bearing length of about 3 in. in order to minimise damping.

The calculated natural frequency, F_n, of the two-mass torsional system is 2,450 vibrations per minute, the effective moment of inertia at each flywheel being 10,600 lb.-in.-sec.² units. The amplitude of the harmonic vibration torque, T_v, in the shaft at any forcing frequency, N vibrations per minute, assuming the system to be undamped, can be shown to be

$$T_v = \pm \frac{0{\cdot}0073N^2}{1 - \left(\frac{N}{F_n}\right)^2} \cdot \qquad . \quad (2)$$

and the amplitude of vibration stress f_v in the test shaft is given by

$$f_v = \pm \frac{T_v}{Z} \qquad . \quad (3)$$

where Z is the polar sectional modulus of the shaft in inch-cubed units. By substitution, it follows that

$$f_v = \pm 48{\cdot}1 \times \frac{\left(\frac{N}{1{,}000}\right)^2}{1 - \left(\frac{N}{F_n}\right)^2}. \qquad . \quad (4)$$

Fig. 9 shows the theoretical undamped resonance curve, a plotted to a base of vibrations per minute. The actual measured resonance curve for No. 1 test shaft, having a butt-welded flange at one end and a fillet welded flange at the other, is shown at b. The measured value of the natural frequency is 2,420 vibrations per minute, and this value has been used for F_n in plotting the theoretical curve from equation (4). The forcing stress in the shaft at 2,420 vibrations per minute is $\pm 96{\cdot}2 \times (2{\cdot}42)^2 = \pm 564$ lb. per square inch; the stress due to forcing torque is shown at c. The measured vibration stress at reonance was found to be ± 16,800 lb. per square inch. Thus, the dynamic magnifier at reonance is $\frac{16{,}800}{564}$, or 30.

In the case of the latest specimen tested, a solid-forged shaft of 28 to 32 tons per square inch tensile strength, it was found possible, with the shaft cold, to reach a stress of about ± 20,000 lb. per square inch, the resonant frequency having increased to 2,620 vibrations per minute on account of the greater shaft stiffness of the solid specimen. The calculated static bending stresses in the 9¼-in. diameter shaft due to the deadweight of the exciter and flywheel are low, being only 2,600 lb. per square inch at the edge of the pedestal-bearing journal, and 1,660 lb. per square inch at the commencement of the flange fillet—a further argument for a short length of test piece. These small steady bending stresses would have negligible influence on the torsional-fatigue strength of the shafts.

In the earlier experiments, with a view to protecting the machine from damage in the event of sudden failure, or excessive amplitude of vibration after the initiation of fatigue cracks, two limit switches were fitted at the perimeter of each flywheel, one on the horizontal diameter to control tangential movement, and one at the top of the vertical diameter to safeguard against bending deflection. The Burgess micro-switches were all wired in series, and operated a relay to open the motor starter switch when the displacement at any one switch exceeded the pre-set value.

From an examination of the resonance curve for the machine, the importance of accurate speed control is evident from the steepness of the curve. Initially, no automatic speed control was fitted to the machine, the regulation of speed being effected by a hand-operated rheostat in series with the motor shunt-field winding.

In carrying out tests on the 9¾-in. diameter shafts described in this paper, the inertia in the machine enabled steady conditions to be obtained in conjunction with this hand control, even on the steep portions of the resonance curve. With rigid supervision, it was possible to maintain the stress steady within ± 5 per cent. of the nominal value in way of the steep portion of the resonance curve. With a view to reducing the amount of supervision necessary with manual control, an automatic electronic system of control has been developed, which has also reduced the variation of stress at the maximum loading to ± 1 per cent. The system of operation is, briefly, as follows. To minimise the effect of wide line-voltage fluctuations experienced with the works direct-current supply, a motor-generator set was installed to operate off the alternating-current supply. The field of the motor driving the harmonic torque exciter is controlled directly by a battery of thermionic power valves operating in parallel. The conductance of these valves is made to vary over a very wide range by means of grid control provided by a control valve. The control signal to the grid of the control valve is obtained in the following manner. A small multi-polar permanent-magnet alternator is coupled solidly to the driving-motor shaft. The signal from this alternator (approximately 300 cycles per second) is amplified and rectified to provide approximately 230 volts direct current. A stabilised direct current of 230 volts is provided as a datum. The driving-motor line voltage, together with the rectified 300 cycles per second signal, are, in correct sense, backed off against the above stabilised datum voltage. The difference signal is then used to swing the grid of the control valve, the grid bias of which is chosen for optimum performance. This system of control, which has recently been developed by Mr. T. W. Bunyan, is an improvement on that adopted in most of the tests; it has been in use in the latest tests (1947), and has functioned very satisfactorily.

At all times during the running of the tests, the strain in the test shaft was indicated directly by means of electric-resistance strain gauges, the stress being derived from measurements of the wave amplitude on the cathode-ray oscillograph. The gauges were affixed to the shaft as shown in Fig. 10, on page 287, *i.e.*, several pairs of gauges on each side of the centre bearing, the straining axes of the gauges being at 45 deg. to the shaft axis. The design described has been found entirely satisfactory so far as the operation of the machine is concerned. It was found, however, that the bolted arrangement of test piece to flywheels was expensive, and, a demand being made for testing cast-iron shafts of 6-in. diameter, a simplified arrangement was designed. In consequence, the form of the test piece has been changed to that shown in Figs. 11 and 12, and the flywheels have been replaced by testing heads as shown in Figs. 13 and 14, page 287. The modified design is simple so far as the machine is concerned; it has proved entirely satisfactory in operation, and will be used for future tests.

Four tests were carried out on welded shafts, three test pieces being used, test shaft No. 2 being formed from test shaft No. 1, by cutting off the flange where failure took place in the butt weld, and welding on another flange. The fillet weld in test No. 2 had therefore previously been subjected to the cycles of stress applied during test No. 1. The tube material of the shaft and flanges was of 26 to 32 tons per square inch quality, and the joints were made by metallic arc welding in accordance with Admiralty Grade A requirements. The welded shafts were stress-relieved at a temperature of 600 to 650 deg. C., and radiographic inspection was carried out by X-ray from outside the shaft, using special screens, and from inside by gamma rays, using radon. Shaft No. 5 was not radiographed, because the porosity in the welds was obvious to the naked eye. After final machining, and before fatigue testing, the shafts were magnetically tested.

The surface finish was ordinary smooth-turned finish, without any polishing process. A shaft, and the types of welded joints, are shown in Figs. 15 to 19, inclusive, page 287. The fillet weld, Fig. 17, and the butt weld, Fig. 18, were used for shaft No. 1; the fillet weld, Fig. 17, and the butt weld, Fig. 19, for shaft No. 2; the butt weld, Fig. 19, was used for both ends of shaft No. 4; and the fillet weld, Fig. 17, for both ends of shaft No. 5. In the case of test shaft No. 1, the butt joint was welded with an oxy-acetylene base run, followed by arc welding with ¼-in. diameter Lincoln "Fleetweld" No. 6 electrodes. Similar technique was used with the fillet weld. In welding on the new flange for test shaft No. 2, a mild-steel backing ring was used and the runs were deposited by arc welding throughout, in the downhand position, the shaft being rotated slowly during welding. Preheating to 400 deg. F. was used for test shaft No. 4, which had both flanges butt welded. In the first run of welding, a ¼-in. diameter electrode was used, while in the remaining 13 runs ⅛-in. diameter electrodes were employed, all electrodes being "Fleetweld." The welding areas were also pre-heated to 400 deg. F. before welding in the case of test shaft No. 5, and slightly different techniques, with "Fleetweld" electrodes, were employed for welding the two flanges. Fig. 20, on page 287, shows the fatigue cracks initiated in test shaft No. 4, and Fig. 21 illustrates those in the case of test shaft No. 5, showing the porosity in the weld. The fatigue test results for these test shafts are given in Table I. They indicate that, unless very special

TABLE I.—*Welded Test Shafts.*

Test shaft No.	Ultimate Tensile Strength of Shaft Material, Tons per sq. in.	Ratio of Shaft diameter to Fillet Radius.	Torsional Stress, Lb. per sq. in.	No. of Cycles.	Remarks.
1	26–32	6·5	± 5,000	2×10^6	Trial run on machine.
			±16,000	96×10^3	Initiation of fatigue cracks in butt weld, from which 45-deg. cracks occurred locally.
			±13,200	72×10^3	
2	26–32	6·5	± 7,000	$9\cdot5\times10^6$	Fatigue cracks in fillet weld. Test abandoned.
			±10,000	8×10^5	
			±12,500		
4	26–32	6·5	± 7,500	$7\cdot2\times10^6$	Cracks developed in one butt weld (Fig. 20, page 287.)
5	26–32	6·5	± 6,500	4×10^6	Cracks developed in both welds (porosity) (Fig. 21, page 287).

care is taken in the welding operation, couplings welded to shafts may have a comparatively low fatigue strength, when subjected to alternating torsional stresses. This may be largely due to lack of homogeneity of the material in the weld area, with resulting increased susceptibility to fatigue failure.

(To be continued.)

NOTES ON NEW BOOKS.

Electrical Materials. Edited by E. MOLLOY. George Newnes Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 5*s.* net.]

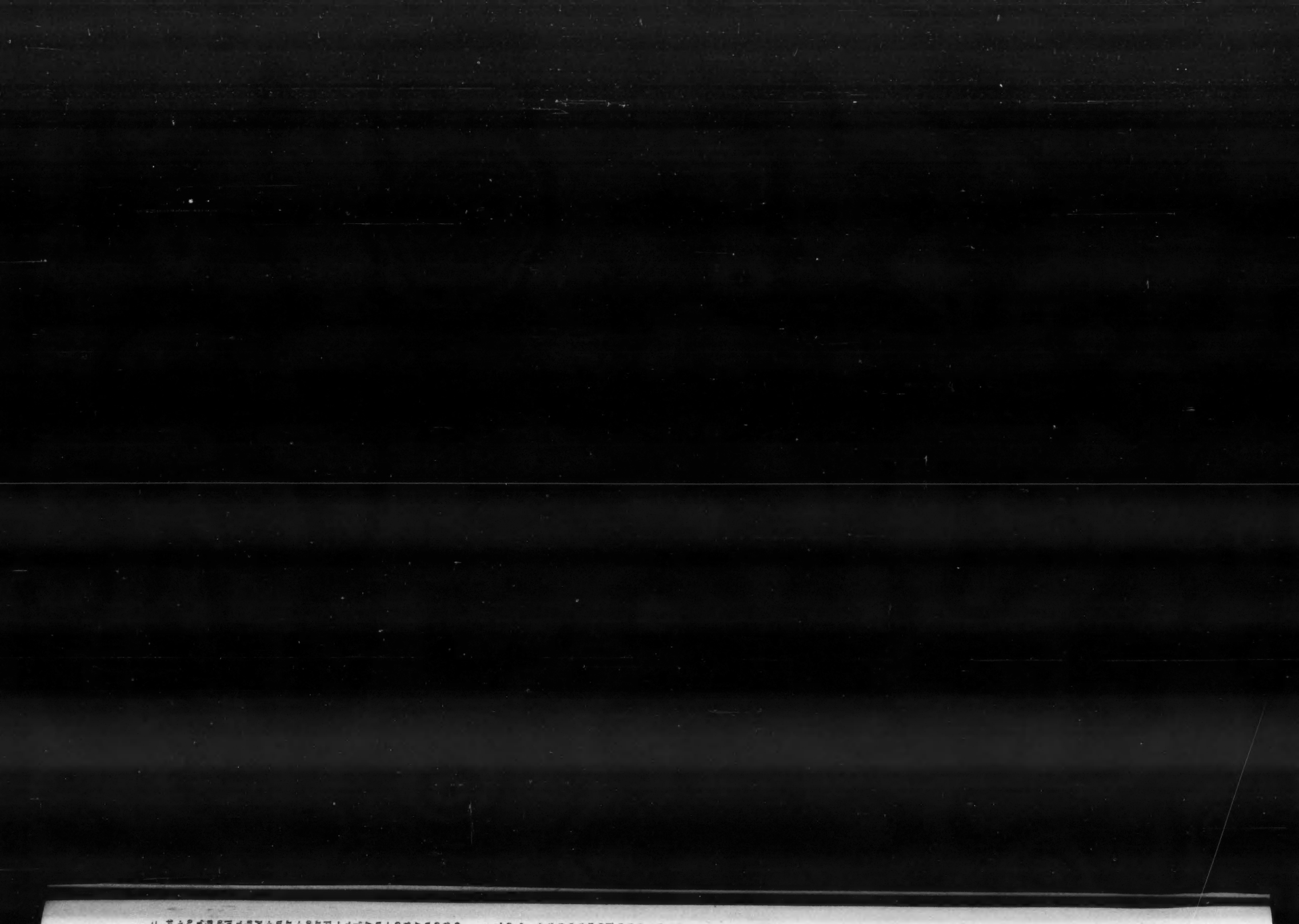
THIS small volume describes the basic properties and uses of materials employed in the electrical industries for current-conducting, magnetic, and insulating purposes. The information is classified under the six main headings of copper, aluminium, rare and precious metals, ferrous and magnetic materials, insulating materials, and manufactured carbon. A list and brief descriptions of some 30 relevant British standard specifications are included. About half of the book is devoted to insulating and di-electric materials, the survey covering gaseous and liquid dielectrics, bitumens and waxes, paints and enamels, ceramics and plastics, cotton and glass, and some details of the silicone resins. The sources from which the graphical data were obtained are not always evident, and, in general, the book would be improved by more frequent citation of authorities, in case additional information should be required; such references as are given relate mainly to British standard specifications. While the book cannot be regarded as a small text-book, it should be useful to those who require a compact summary of the functions of electrical materials, especially insulating materials, and the factors which should influence their selection.

The J. and P. Switchgear Book. By R. T. LYTHALL, M.I.E.E., A.Am.I.E.E. Fourth edition. Johnson and Phillips, Limited, Victoria Works, Charlton, London, S.E.7. [Price 25*s.* net; for educational authorities, 20*s.* net.]

THIS book is described by the author in his preface as "an outline of switchgear practice for the non-specialist user and for students." The use of the word "outline" is evidence of modesty; the book contains 645 pages and some 580 illustrations. In the sense that every detail of every type of switchgear is not dealt with, the book is an outline, but no treatise covering every aspect of an extensive branch of engineering has ever been written, or ever will be. The chapter of this book dealing with air-blast circuit-breakers extends to 43 pages and includes 42 diagrams, detail drawings and photographic illustrations; it constitutes a complete review of its subject on broad lines and describes the various current-suppression arrangements which are in use. It is not a specialist's treatise on arc extinction, but it is a very well filled-in outline. This comment applies to the book as a whole, and oil circuit breakers, fuses, outdoor switchgear, instruments, protective systems, remote-control arrangements and other features of its wide subject are dealt with on the same informative but non-specialised lines. The majority of people who have to do with switchgear are neither designers nor makers, and the broad, but inclusive, treatment to which it is subjected in this volume will be of value to a large circle. Although the book is published by a commercial firm, it is in no way a catalogue of that firm's products. It is a technical treatise in the full sense, and deals with the practice and illustrates the manufactures of all, or most, of the leading British makers of switchgear and its ancillary apparatus. Perhaps more than any other major item of electrical plant, switchgear offers a wide variety of choice of type and, consequently, for differences of opinion, and while in the long run the purchaser must decide what class of gear he will install, the "non-specialist user" will be assisted in coming to a decision by Mr. Lythall's fair presentation of the cases to be made for alternative methods. This fourth edition of the book contains the material, with much additional matter, which was previously contained in two volumes. The first issue appeared in 1938, followed by a reprint in 1939. Later developments in the subject, and a decision to increase the scope of the book, led to a further issue in 1943, but owing to the paper situation at that time the new material appeared in a separate volume. This led, in the author's words, "to an untidy mixture where material in the second volume was additional to that in the first." Opportunity has now been taken to present this revised and self-contained volume.

Practical Design of Simple Steel Structures. Volume I. Third edition. By DR. D. S. STEWART. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 15*s.* net.]

IN this new edition the contents of volume I are very much as they were in previous editions, except that the structural tables, formerly published separately as Volume III have now been included in Volume I. The ground covered includes shop practice and the design of riveted connections and beams. The author assumes that the reader has only a slight knowledge of the theory of structures and none at all of rolled-steel sections or of shop practice; therefore, the book is essentially one for beginners. Riveted connections are dealt with in some detail and separate chapters are devoted to simple riveted joints, flange-plate splices, splices for angles, joists and channels, splices for the web plates of plate girders, and eccentric riveted connections. The method followed is that of giving the full design calculations for each of the designs considered, and the reader who works through these calculations should obtain a fair idea of the procedure employed. A short chapter on wind pressure and factors of safety is followed by a long one on beam design, and a final chapter is devoted to the complete design of a joist and channel crane-gantry girder. The item in the index "non-symmetrical bending moment" is rather startling, and certain other errors still remain. The book should, however, be useful to the category of readers for whom it has been written.

Low-Pressure Laminating of Plastics. By J. S. HICKS and R. J. FRANCIS. Rheinhold Publishing Corporation, 330, West 42nd-street, New York 18, U.S.A. [Price 4.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 27*s.* net.]

A BROAD, and as yet largely unexploited, industrial field exists for plastic articles that, on account of size or shape or small numerical demand, cannot be made profitably by elaborate and costly machinery. Such products, exemplified by aircraft parts, boat hulls, hand luggage, and electrical accessories, are now being made successfully from resins which cure at relatively low temperatures and pressures. Typical fabrication comprises a multi-ply reinforcement of textile fabric, fibre glass or paper which is impregnated with an appropriate thermosetting resin, and cured to form an integral whole while maintained in contact with a mould. The authors pay special attention to contact pressures up to one atmosphere, for which "flexible bag" techniques are suitable, and to reinforcing or filling agents of spun glass, but they cover also a representative range of materials and processes, including post-forming from laminates by pressure moulding, light-weight sandwich constructions, and structural combinations of laminated plastics with wood and metal. Their strictly practical treatment deals with every aspect of the subject, from the fashioning and preparation of the original mould to the colouring and trimming of the final plastic. The copious references to published accounts of individual processes and commercial sources of materials and special tools are almost exclusively American, but otherwise the book affords generally valuable guidance and should prove especially stimulating to technicians already engaged in other methods of plastics manufacture.